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SIXTEENTH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

TO THE

SECRETARY OF THE INTERIOR

1894-95

CHARLES D. WALCOTT
DIRECTOR

IN FOUR PARTS

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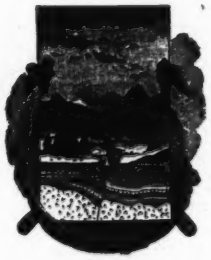

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THE PUBLIC LANDS AND THEIR WATER SUPPLY.

BY

FREDERICK HAYNES NEWELL.

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THE PUBLIC LANDS AND THEIR WATER SUPPLY.

By FREDERICK HAYNES NEWELL.

INTRODUCTION.

Questions as to the best methods of utilization and disposal of the vacant public lands have been of great prominence ever since the birth of the Republic, and the inauguration of a wise and judicious system of land laws has been deemed one of the noteworthy achievements of the early part of the century. Many questions, however, are still far from being finally settled; for with the rapid changes incident to the growth of the nation, the settlement of the Mississippi Valley, and the construction of many transcontinental lines of communication leading to the highly cultivated and thickly populated lands of the Pacific Coast, new conditions have arisen to which former precedents and customs are no longer applicable.

While the well-watered lands stretching from the Ohio to the Missouri were open to settlement, the problems were mainly those of administration; but now that the humid lands are disposed of, and pioneers are pressing forward to every part of the vast interior region where water and not land is the first item of value, it becomes necessary to modify the treatment of the public lands and to introduce better methods. Such necessary improvements, or the introduction of systems leading to greater prosperity, must depend to a large extent upon the possession by the general public of broad yet accurate knowledge of the chief characteristics of the remaining public domain. This knowledge can be obtained only by a thorough scientific examination and an impartial statement of the facts as ascertained by disinterested observers.

There is still vacant and open to settlement within the boundaries of the United States (not including the Territory of Alaska) an area comprising nearly 630,000,000 acres, or one-third of the total extent of the country. This vacant land is not wholly unutilized, since a great proportion of it is of value for grazing purposes and sustains large herds of cattle and flocks of sheep. No rent or fee is paid by the owners of these herds and flocks, the range being free to all, and as a consequence the business of grazing has increased to such an extent that

the ranges are overstocked, and in places the extermination of valuable native grasses is threatened. The owners of these wandering cattle and sheep are often nonresident, have little or no interest in the permanent development and improvement of the country from which their wealth is drawn, and may even use their influence—strong through concentration in the hands of a few—toward the retardation of settlement and the building of homes.

Within the vast extent of vacant public lands there is also an unknown area—amounting to scores of millions of acres—of forests and wooded lands, whose products are of primary importance in the development of civilization at innumerable points. These forests and woodlands belonging to the nation have no protection; they are subject to depredation on every side, and, incomparably worse than this, to the ravages of fires kindled by careless or malicious persons.

The land laws of the United States provide for perhaps the best method of disposing of the fertile, well-watered prairies, plains, and slopes of the Mississippi Valley. There the results have been happy, and prosperity has followed the rapid acquisition of homesteads by thrifty and energetic settlers; but the conditions now are almost wholly changed. These broad acres, so well adapted to subdivision by the rectangular system, and which, when thus subdivided, have an almost equal value at every point, have now passed out of the possession of the National Government; and although an enormous area still remains—an area three times as great as the aggregate of the thirteen original States of the Union—it can not be expected that the continued application of methods and rules proper for the humid region will be followed by prosperity and the best results to the average settler. This has been pointed out again and again within the past decade, and was dwelt upon by Major Powell and his assistants in their notable report upon the arid region.[1] The needs pointed out by this report become more pressing as the small remaining area of humid lands is taken up and the vacant public lands are found to embrace only those of arid or semiarid character.

It is not, however, the intention in this paper to dwell upon the land system of the United States, nor to make suggestions as to its modification, but simply to point out the location of the public lands, to indicate in a general way their extent and position, and to lay before the public such facts as have been obtained concerning their broader physical characteristics, and especially their water supply. The latter is still a subject of investigation, and although considerable work relating to it has been done, in view of the enormous extent of country to be traversed it can hardly be said to be more than inaugurated. This discussion of the location and extent of the vacant public lands is intended to be by no means exhaustive, but is designed rather to serve as a guide in matters

[1] Report on the Lands of the Arid Region of the United States, with a More Detailed Account of the Lands of Utah, with Maps, by J. W. Powell, Washington, 1879.

pertaining to a thorough study of the possibilities of utilization of the resources of the national domain.

In what has been known as the organic law of the Geological Survey, approved March 3, 1879, it is provided that the officer in charge of the Survey shall have direction of the classification of the public lands. Such classification, however, will be possible only after an exhaustive study of the geography and geology of the country has been made and a thorough knowledge of the processes involved in the best utilization of the natural resources has been gained. This classification is therefore by no means so easy or simple as might be supposed, and at the same time it is an undertaking of great importance to the nation at large. To make a useful classification, to point out the possible value of millions upon millions of acres of wild and unsettled lands embracing every variety of topography, of climate, and of geological structure, is a stupendous task. The first requisite is a good map; next, a knowledge of the structure, rocks, and soils; and with these, some information regarding the most essential and yet the most fluctuating form of mineral wealth—the water supply. Through the broad conceptions and the indomitable persistence of the founders of the Geological Survey, the mapping and the study of the existing conditions have proceeded rapidly, and the public is now able to ascertain the facts regarding the physical conditions of large portions of the national domain. The work is well under way, but to comprehend its magnitude, when applied only to the unoccupied lands of the United States, it is necessary to have clearly in mind the location and character of these lands.

The need for a general map of the vacant areas was early recognized, but the numerous difficulties seemed to preclude such an undertaking. The attempt to ascertain what and where the public lands of the United States are is a matter of difficulty and expense, and considerable dissatisfaction has arisen from the uncertainties of the determinations already reached. Upon the books of the General Land Office is entered the status of each parcel of land which in any way has been reserved, filed upon, or disposed of; but these ledgers number thousands, and embrace almost innumerable entries in a state of suspension, awaiting rulings or decisions. It would require the services of a hundred experienced clerks for a number of months to abstract from these books and tabulate with any degree of accuracy the figures relating to vacant lands. Such a task, unless authorized by special act of Congress, could not be undertaken. A shorter method was, however, suggested, and through the special interest of Maj. J. W. Powell, then Director of the Geological Survey, a number of employees in this Bureau were detailed to rapidly examine the more important tract books and to check off upon a map of each State the larger groups of entries. The result was a graphic representation which is sufficiently accurate for the small generalized map (Pl. XXXV) herewith presented.

For a number of years the reports of the General Land Office have

contained estimates, by counties, of the vacant public land in each land-office district. Some of these estimates are prepared carefully and conscientiously, while others are not. In the following tables, showing the extent of the public lands, the figures published in the annual reports of the General Land Office have been used whenever inspection indicated that they had been carefully prepared. Where, however, it was evident that these figures were not complete, new computations were made, based upon the disposals of the public lands for the last thirty years. By this means it is believed that the figures herein presented have been made reasonably accurate.

LOCATION AND EXTENT OF PUBLIC LANDS.

The map, Pl. XXXV, made in the manner described, exhibits graphically the location and extent of the public lands of the United States. The red color indicates the lands formerly owned by the General Government which have been sold, granted, or disposed of in various ways to individuals, to States, and to corporations. The uncolored portion, consisting in the eastern part of small, inconspicuous dots, and in the western of large areas, designates the lands now belonging to the General Government and open to entry and settlement under the various land laws. The bands of cross-hatching extending across the western part of the country show the areas within which every alternate section has been given to railroad companies to aid in the construction of the transcontinental lines. The smaller similarly marked areas in Oregon indicate the grants for the construction of military wagon roads. Indian and forest reservations are also shown on the map, by green and orange, respectively.

The relative area of these various classes of public land, as compared with the whole of the land area of the United States, is shown by the following table and in the diagram, fig. 48, these figures being totals, the details of which are given later under various headings. The table gives these areas both in square miles and in acres, since it is sometimes convenient to use one and sometimes the other of these units. The areas are also expressed in percentages of the total land area of the United States, in order to show more clearly their relative magnitude.

Relative extent of the public domain.

	Square miles.	Acres.	Per cent.
Vacant public lands	980,337	627,415,680	33.01
Indian reservations	131,689	84,280,960	4.43
Forest reservations	30,445	19,484,800	1.03
Lands disposed of	1,107,044	708,508,160	37.27
Area of older (19) States	458,195	293,244,800	15.43
Area of Texas	262,290	167,865,600	8.83
Total land area of United States	2,970,000	1,900,800,000	100.00

As shown by the above table, the vacant public lands comprise 980,337 square miles, or 627,415,680 acres, this being 33.01 per cent of the total area of the United States, exclusive of Alaska, or very nearly

one-third of its land surface. The character of this vacant land and its distribution according to States and Territories are discussed at some length in the following pages. A small proportion of this land will probably be claimed in the future by transcontinental-railway companies as part of the grants made to aid in the construction of their roads, or as indemnity for sections to which title can not be obtained. But this amount is relatively small. Of this vacant public land 26,822 square miles (p. 477), or 17,166,080 acres, are in the eastern part of the United States. This quantity is only nine-tenths of 1 per cent of the total area of the United States. The remainder of the vacant land, as previously stated, is in the West, and is mainly within the arid regions.

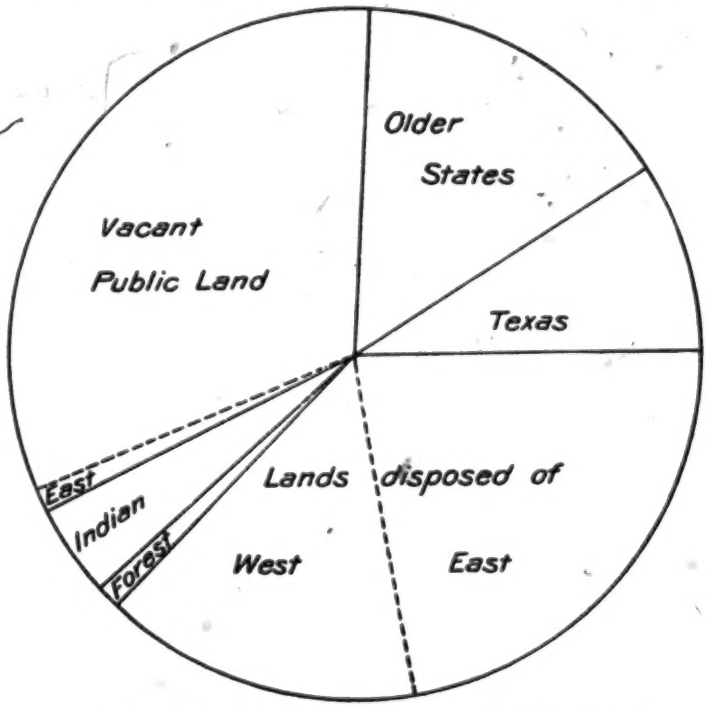


FIG. 48.—Diagram illustrating relative area of public land vacant.

Under the head of Indian reservations the table shows 131,689 square miles, or 4.43 per cent of the total area of the United States. Under this designation is included, however, the whole extent of the Indian Territory, and also the military reservations of the West, the latter amounting to 2,456 square miles. These figures are discussed more in detail on pages 490–492. Each year portions of tracts of land held as Indian reservations are allotted in severalty and the balance thrown open to settlement, so that in any consideration of the vacant

public lands an allowance should be made for a slight increase from the Indian reservations.

The forest reservations are a new institution, having been created by act of Congress of March 3, 1891.[1] Under this head has been included the Yellowstone National Park, as from its character and location it can best be classified in this category. The total extent of these reservations, including the Yellowstone Park, is only a trifle over 1 per cent of the whole area of the United States, and 13.21 per cent of the estimated extent of forest land of the Western States and Territories (p. 482).

The area disposed of is the balance obtained after deducting the vacant public lands, the various reservations, and the areas of the States having within their borders no lands belonging to the National Government. The total amount disposed of, as thus obtained, is 1,107,044 square miles, this being 37.27 per cent of the total land surface of the country. Of this amount 671,728 square miles, or 60.68 per cent of the total disposed of, is in the eastern part of the country, and the remainder, or 39.32 per cent, is in the West, these terms being defined, as used in this connection, on page 475.

The diagram, fig. 48, exhibits these facts in concise form. The circle is intended to represent by its area the entire land surface of the United States. This is divided into a number of sectors, proportional to the areas of the various classes of land. The area of the older States is shown to be relatively small, the single State of Texas being over half as large as all of the nineteen States forming the Union in the early part of this century. The sector showing the lands disposed of is divided by a dotted line indicating the relative amounts in the East and the West, and in the same way the sector showing vacant public lands is divided by a dotted line bringing out the relatively small proportion in the East.

IMPORTANCE OF HYDROGRAPHIC DATA.

By far the greater portion of the vacant public lands— over 95 per cent—are classed as arid or semiarid in character, and depend for their future value not so much upon altitude, mineral contents, or geological structure as upon the presence or absence of water. Thus it is that the question of water supply, its quantity, quality, and availability, is one upon which pivots the future of the national domain. When the essential facts concerning the water are clearly known, it will be possible to determine upon the best legislation for the reclamation of portions of this vast area and the dedication of other portions to various purposes, as for grazing and woodland. It is a fact now generally recognized that, owing to the scarcity of water, only a small proportion of the public domain can be reclaimed for agriculture, but this amount, though small when compared with the whole

[1] Statutes at Large, vol. 26, section 24, p. 1103.

area, is in the aggregate larger than the territorial extent of some of the States, and will sustain a population numbering millions. After all of the land that the water will cover has been utilized for agriculture by means of irrigation, there will still remain hundreds of millions of acres of rich land suitable for grazing and for the growth of forest products.

That the solution of the problems relating to the public lands of the United States depends upon a thorough knowledge of the hydrography can best be shown by a brief review of the conditions prevailing throughout the region where the greater part of this land is situated. At this time reference will not be made to the unoccupied tracts in the East, whose utilization depends to a large extent upon drainage, but to the great bodies of land within the western half of the United States whose one great need is that of water.

The streams within the arid regions of the United States have their sources amid the high, rocky, or forest-clad slopes of the mountains, and descend rapidly toward the fertile plains. Their downward course is seldom an uninterrupted one. Usually at one point or another they meander for a time through upper valleys or parks whose summer verdure is in striking contrast to the sunburned plains below. Leaving these, the streams enter rocky defiles or narrow canyons, to emerge upon a narrow lower valley, and, receiving tributaries on the way, they finally pass through the foothill region and out upon the vast fertile plains. At about this point a gradual transition takes place in the character of the channel, which, from a rocky, torrential, or gravelly stream-bed with rapid fall, broadens to a shallow, shifting, sandy channel, in which the stream, dividing and subdividing in times of low water, finally, by imperceptible degrees, loses itself. In times of flood the water may fill the broad, sandy waste and after a few days force its way far out to join some lake, or finally reach some perennial stream making its way to the ocean.

The water of the stream may be diverted at any point in its course. It may be taken out in the upper parks or valleys, high among the mountain peaks, and used during the spring or summer to increase the growth of the forage plants; or it may be utilized in the lower valleys among the foothills, or out upon the margin of the plain, or upon the lower plain itself. If the stream channel were like an iron pipe or conduit, in which the water, once received, must pass along until discharged into some branch or at the lower end, the consideration of water supply would be comparatively simple. It would be assumed that whatever water came into the pipe at any point must come out at some other, or, in other words, that the quantity to be dealt with would be constant, and our account books would balance. This, however, is not the case in nature. If among the mountains we measure all of the visible affluents of a stream and add together these measurements, and then measure the volume of the main stream a little distance below, we shall

generally find that the latter volume is greater than the sum of the visible tributaries. Water has come in imperceptibly. This action continues through a large part of the year, after the frost has left the ground and until late summer. Downstream, however, at the borders of the plain, the conditions are different. If at the edge of the foothills we measure all of the creeks, add together the measurements, and then measure the main stream a few miles below, it will usually be found that this latter volume is less than the sum of the various tributaries, and that this decrease continues at a greater or less rate, with perhaps an occasional increase.

This irregularity in the behavior of a stream in increasing and decreasing without visible cause is explained by what is commonly known as seepage or percolation. In the more elevated portions of the basin, with cooler climates and larger water supply, the rocks, more or less saturated, yield their waters to the streams, while in the lower and dryer part of the basin, the rocks and soils, being loose or unconsolidated, draw away some of the water, until all may be taken up and passed along and out into the atmosphere. Direct evaporation from the surface also diminishes the flow of streams in their lower courses, but this factor is relatively small and need not be dwelt upon here.

Under natural conditions, therefore, a stream gradually increases in volume, both by tributary surface streams and by percolation, and then gradually loses this volume by imperceptible degrees. There is thus a point where the stream, during medium stages, has greatest volume, and where losses are most negligible. This point is usually at or near the lower foothill region, and in a general way coincides with the place where, from slope of channel and other topographic features, canals and ditches can be most economically constructed to carry water out to the edge of the lower plain. This locality has other favorable conditions. Being protected by the foothills, its climate is often better than that of regions farther out upon the plain; the winds are not so severe, and the frosts do not come so early in the fall or linger so late in the spring.

Thus it is that in respect to character of soil, to climate, and to water supply and its economic use this part of the river basin is peculiarly favored for successful agriculture by irrigation; and if physical conditions only were to be considered, a proper distribution of efforts at such places would result in the largest and best utilization of the vast extent of public lands. Under the gradual development of agricultural interests, however, settlement has not taken place so as to produce the greatest good for the greatest number, partly on account of lack of broad knowledge of all of the facts, but more because individual necessities and individual choice governed the first undertakings. Thus it is that on each stream the best lands and the best opportunities for utilizing the water in a large way have often been neglected

and their utilization has been prevented for all time by innumerable petty projects or by adverse acquired rights.

The progress of settlement has been very irregular. A prospector weary with the search for precious minerals, a cattleman choosing a home ranch, or a pioneer farmer seeking a location with ample space for his growing family, has picked out what seemed to him at the time the most desirable spot, and by his own efforts, or aided perhaps by neighbors, has dug a small ditch where the ground was most easily worked by simple farm tools. Above or below another ditch has been taken out, and year by year, as more people settled along the stream, new ditches have been dug, far up the valley or lower down, and old ones have been enlarged. The taking out of the water by these little ditches and the resulting saturation of the ground has modified the natural seepage, and in the higher part of the stream channel, at least, the water taken out and put upon the ground in the early part of the season tends to find its way back to the channel later in the year. This is especially the case with the first or earlier ditches, for there being usually plenty of water in these, an amount in excess of the needs of the crops is used, and when the ground can hold no more this excess must be slowly distributed and finally, following the natural slopes, be discharged at the lowest points into the natural drainage lines. The tendency of such ditches, having drawn upon the spring flood and carried the water out upon the lands, is to add to the low-water seepage, or, in other words, to increase the volume later in the year. This tendency is now well recognized, and is often esteemed a benefit to lower portions of the valley, since it slightly diminishes the overflow in the spring, but more especially it is valuable by adding to the late summer discharge at times when the need of water is greatest.

The benefits to be derived from seepage water are, however, apt to be overestimated, and too great importance is likely to be assigned to them, especially by persons so located upstream that they have first use of the water. Take, for example, the typical catchment basin above described, in which there is a broad upper valley, a long middle or lower valley, and beyond this the broad expanse of margin of the plain. Inhabitants of the highest valley, by turning out water during the spring flood and distributing it over pasture or hay lands, put to beneficial use waters which otherwise would be wasted, since at that season there is an excess all along the stream. A part of the water thus utilized percolates back to the stream and adds to the volume available for the irrigators in the middle valley. If, however, this utilization in the highest valley continues throughout the summer, when the heat and consequent evaporation is greater, it may be possible to divert all of the flowing water from the stream by spreading it upon the fields, leaving the channel completely dry save for the seepage, which continues to flow. Then the inhabitants of the middle valley are deprived of the natural flow of the stream, and have only the seepage water, instead of

the ordinary discharge increased by seepage. There is thus a time shortly after the occurrence of the spring floods when continued utilization of the waters in the highest valley becomes not a benefit, but an injury, to the people below. The same thing is true of the utilization of the water in the middle valley. The extravagant use of the water early in the year in the middle valley may be of advantage to those below, by adding to the summer flow through seepage, but such use later in the season interferes greatly with the supply at points farther downstream by taking all of the water out of the stream.

There is for every point along a river of any considerable length a time when the diversion of the water at points far above becomes not a blessing, but a curse. This time varies not only with the amount of water in the stream and the amount taken out, but also with the weather conditions, a dry year resulting in diminished seepage and earlier passage of the critical point, and a cool year in retardation of the time when diversions above become an injury. This date, as a rule, gradually grows earlier and earlier as years go by, for with the usual extension of irrigating systems comes greater economy in the use of water, and with greater economy there must be less seepage. A smaller amount of water is put upon the fields, and finally only enough to supply the needs of the plants. When this point is reached there should theoretically be no artificially induced seepage, and then no benefit to points below. This, however, is an extreme condition, rarely realized. Although this critical time is somewhat uncertain and variable, it is essential that it be determined in a general way, if the rights of all persons are to be preserved and the farmers are to have protection in their water rights at all comparable to the security enjoyed in land titles.

The necessity of ascertaining not only the water supply, but also the modifications due to artificial diversion of the water, is emphasized by consideration of the prevalent customs and usual legislation regarding water rights. As a rule, throughout the arid region priority of utilization carries with it the first right to continued employment. The man who along the course of the stream first took out water and cultivated a given piece of land is by custom and law entitled forever to take out the same quantity of water to this land, regardless of his neighbors. The man who came second, whether by a day or by a generation, has a secondary right, and can use forever the amount of water originally diverted and put upon the cultivated soil, provided there is sufficient to supply the first comer. The man who is third in point of time can utilize his share only after the first and second men have had their prior claims satisfied; and so on down the list, the last comer being compelled, if necessary, to leave the water untouched until all have had the exact quantity legally claimed.

The above somewhat detailed discussion of one of the problems of water distribution illustrates the difficulties in the way of the best

development of the arid lands, and shows the necessity of thorough and accurate knowledge of all the conditions. The matter is further complicated by the manner in which political divisions have been drawn regardless of natural boundaries. In nearly all cases the more important streams flow through several counties, each of which has its own peculiar custom in regard to the distribution of water, and in each the inhabitants and officials are somewhat jealous of other counties, or at least are not inclined to work in harmony with them. The most difficult cases, however, are where State lines intersect drainage basins, as it is then almost impossible to secure any consideration by one State of the rights of people lower down the stream in another State. Each year these interstate questions are becoming more and more complicated, and the demand for laws or regulations which shall impartially settle the disputes is more urgent.

There are also important streams, such as the Rio Grande, which flow along or across the borders of the Republic and give rise to international complications similar in many respects to the interstate questions. While in each case there is necessity for accurate and detailed information regarding local conditions, yet it should be possible to determine some broad principles applicable to all. A thorough knowledge of the water supply, its fluctuations and limitations, is therefore essential, from whatever aspect the future of the public lands may be considered; but the difficulty of obtaining such systematic knowledge can not well be appreciated unless the vast extent and wide distribution of the national domain are considered. A conception of this can be best obtained by a brief examination of the relative areas of the various component parts of the United States.

AREA AND GROUPING OF THE SEVERAL STATES.

In this paper the figures relating to the areas of the several States and Territories are those given by Mr. Henry Gannett in Census Bulletin No. 23, dated January 21, 1891. According to this bulletin the total area of the United States, exclusive of Alaska, is 3,025,600 square miles. Of this 55,600 square miles is water surface, leaving 2,970,000 square miles of land surface. This is equivalent to 1,900,800,000 acres. For the purposes of this discussion the States may be considered in a number of groups, depending upon their relation to the public lands. The thirteen original States retained control of the lands within their present borders, and these lands, therefore, never formed a part of the national holdings. The total area of these thirteen States, including the District of Columbia, as shown on the next page, is 312,770 square miles, or 200,172,800 acres, this being a little over one-tenth of the present area of the United States.

Since the formation of the Union five States have been admitted within whose limits the National Government held no land. One of these—West Virginia—was cut off from the State of Virginia, while

the other four embraced lands claimed by one or another of the original States. The aggregate area of these five States is 145,425 square miles, this being a little less than 5 per cent of the present area of the country. At the time of its annexation the State of Texas was an independent Republic, and under the terms of admission it retained possession of the lands within its borders. The State has had its own land office and system of administering public lands, so that its addition to the Union did not increase the extent of the national holdings. Although the conditions are somewhat similar to those in the admitted States above mentioned, yet Texas, on account of its position and large size, can not well be grouped with these, but stands by itself. For convenience of reference the following table gives the area of the land surface of the thirteen original States and of the five States admitted later within which the National Government has not owned the vacant land, and also of Texas:

Area of the land surface of the older States.

States.	Square miles.	Acres.	Per cent of land area of United States.
New Hampshire	9,005	5,763,200	.30
Massachusetts	8,040	5,145,600	.27
Rhode Island	1,085	694,400	.04
Connecticut	4,845	3,100,800	.16
New York	47,620	30,476,800	1.60
New Jersey	7,455	4,771,200	.25
Pennsylvania	44,985	28,790,400	1.51
Delaware	1,960	1,254,400	.07
Maryland	9,860	6,310,400	.33
Virginia	40,125	25,680,000	1.35
North Carolina	48,580	31,091,200	1.63
South Carolina	30,170	19,308,800	1.02
Georgia	58,980	37,747,200	2.00
District of Columbia	60	38,400	.....
Total, 13 States and District of Columbia	312,770	200,172,800	10.53
Kentucky	40,000	25,600,000	1.35
Vermont	9,135	5,846,400	.30
Tennessee	41,750	26,720,000	1.40
Maine	29,895	19,132,800	1.01
West Virginia	24,645	15,772,800	.83
Total, 5 States	145,425	93,072,000	4.89
Texas	262,290	167,865,600	8.83
Total, 19 States and District of Columbia	720,485	461,110,400	24.25

Deducting the nineteen States above mentioned and the District of Columbia, there are left the public-land States proper, including with these the Territories. These comprise in area a little over three-fourths of the whole extent of the United States. The lands within their borders have, since the birth of the Republic, been a source of revenue and of strength. The common interest in this vast property has been a tie to bind the sometimes clashing interests of the various sections, and the broad extent of fertile lands has served to divert and turn to account the energies of the overcrowded or restless population of the East.

Of the public-land States there are only four in which all of the vacant land has been disposed of. These are Illinois, Indiana, Iowa, and Ohio. The remaining States and Territories have from less than 1 per cent up to 99 per cent of their area still vacant. These remaining States arrange themselves naturally into two groups, the Eastern and the Western. Under the head of Eastern States are included all those lying east of the center of the country. As the map of the United States is usually drawn, the ninety-seventh meridian forms the central vertical line. On the north this coincides approximately with the position of the Red River of the North, forming the boundary between northern Minnesota and North Dakota. South of this river, a series of State boundaries forms an irregular line having a trend slightly to the east of south to the Gulf of Mexico. This somewhat arbitrary line affords a convenient means of dividing the public-land States, since it separates as a whole the humid States from those which are wholly or in part arid or subhumid. The natural line of demarcation between these great climatic divisions lies somewhat farther west, but is nowhere sharply defined, and may be considered as oscillating year by year, backward and forward, over a considerable belt of country. On account of this uncertainty as to the natural division, it is necessary in discussing the public lands to take some such fixed line as that afforded by the State boundaries. Nearly all of the public lands to the east of this line are not only well watered, but many of them are swampy in character, while the greater part of the public lands to the west are arid and almost desert-like.

The following tables give the area of the States of the two groups above mentioned, both in square miles and in acres, and the size of these as compared to the country as a whole. On inspection, it will be seen that over one-half of the area of the country is included within the Western public-land States and Territories, and in this connection it should be stated that 61.48 per cent is still unoccupied.

Area of the land surface of the Eastern public-land States.

States.	Square miles.	Acres.	Per cent of land area of United States.
Alabama	51,540	32,985,600	1.74
Arkansas	53,045	33,948,800	1.79
Florida	54,240	34,713,600	1.83
Illinois	56,000	35,840,000	1.88
Indiana	35,910	22,982,400	1.21
Iowa	55,475	35,504,000	1.87
Louisiana	45,420	29,068,800	1.53
Michigan	57,430	36,755,200	1.93
Minnesota	79,205	50,691,200	2.67
Mississippi	46,340	29,657,600	1.56
Missouri	68,735	43,990,400	2.31
Ohio	40,760	26,086,400	1.37
Wisconsin	54,450	34,848,000	1.83
Total Eastern States	698,550	447,072,000	23.52

Area of the land surface of the Western public-land States and Territories.

States.	Square miles.	Acres.	Per cent of land area of United States.
California	155,980	99,827,200	5.25
Colorado	103,645	66,332,800	3.49
Idaho	84,290	53,945,600	2.84
Kansas	81,700	52,288,000	2.75
Montana	145,310	92,998,400	4.90
Nebraska	76,840	49,177,600	2.59
Nevada	109,740	70,233,600	3.69
North Dakota	70,195	44,924,800	2.36
Oregon	94,560	60,518,400	3.18
South Dakota	76,850	49,184,000	2.59
Washington	66,880	42,803,200	2.25
Wyoming	97,575	62,448,000	3.29
Total Western States	1,163,565	744,681,600	39.18
Territories.			
Arizona	112,920	72,268,800	3.80
Indian Territory	31,000	19,840,000	1.04
New Mexico	122,460	78,374,400	4.12
Oklahoma	38,830	24,851,200	1.31
Utah	82,190	52,601,600	2.77
Total Territories	387,400	247,936,000	13.04
Total Western States and Territories	1,550,965	992,617,600	52.22

EASTERN PUBLIC-LAND STATES.

AREA AND RATE OF DISPOSAL OF VACANT LANDS.

The table on page 477, compiled from the report of the General Land Office, gives the area of public lands vacant in the States lying east of the center of the country, except in Illinois, Indiana, Iowa, and Ohio, where there are no longer any vacant lands, the National Government having disposed of its possessions in these four States. In the nine remaining States the vacant area varies from a little under 1,000 up to 8,787 square miles. The aggregate amount is 26,822 square miles, or 17,166,080 acres, this being 5.25 per cent of the total area of the nine States within which this land is situated. The figures given under the head of "Rate of disposal" show the average number of square miles to which title has been acquired annually by individuals or corporations during the past five years. They represent the rate at which the vacant land is passing out of the hands of the General Government, although this rate has been varying, and as a whole decreasing. The ratio which these disposals bear to the lands remaining vacant is also shown in the table, varying by States from over 37 per cent in Wisconsin to less than 6 per cent in Arkansas. As a whole, the rate has been 11.58 per cent; or, in other words, if this rate should be maintained, all the lands would be disposed of in about nine years. As previously stated, however, this rate tends to decrease as the better land is exhausted; but it is safe to assume that within a decade the amount of vacant public land within these States will be insignificant.

Nearly 60 per cent of the total area vacant lies in the States of Arkansas and Minnesota. Next to these come Florida and Louisiana; and then, in order, Missouri, Mississippi, Alabama, Wisconsin, and Michigan. Much of the vacant land in the two States first named is rugged and timber-clad, with a soil reputed to be too poor for successful agriculture. On the other hand, in Florida and Louisiana the greater part of the vacant land is swampy and can be reclaimed, if at all, only at considerable expense for drainage canals and dikes or levees to prevent overflow. In the remaining States the lands are largely timbered, and some of them may be valuable not only for forest products but also for agricultural purposes. In all of the States these tracts of vacant land are, as a rule, widely scattered in relatively small bodies, and are not in such condition as to attract the settler.

Total land surface, area vacant, and the rate of disposal in Eastern public-land States.

States.	Total land surface. a	Lands vacant.		Rate of disposal.		
		Area.	Per cent of land surface.	Annual average in five years.	Per cent of vacant lands in State.	Per cent of total area of State.
	Sq. miles.	*Sq. miles.*		*Sq. miles.*		
Alabama	51,540	1,258	2.44	404	32.11	0.78
Arkansas	53,045	7,238	13.64	407	5.62	.77
Florida	54,240	3,141	5.79	300	9.55	.55
Louisiana	45,420	1,660	3.06	314	18.91	.69
Michigan	57,430	986	1.73	164	16.63	.28
Minnesota	79,205	8,787	11.09	643	7.32	.80
Mississippi	46,340	1,307	2.82	355	27.16	.77
Missouri	68,735	1,400	2.04	323	23.07	.48
Wisconsin	54,450	1,045	1.91	197	37.86	.36
Total	510,405	26,822	5.25	3,107	11.58	.61

a These figures are from Bulletin No. 23 of the Eleventh Census, prepared by Henry Gannett, dated January 21, 1891.

WESTERN PUBLIC-LAND STATES.

AREA AND RATE OF DISPOSAL OF VACANT LANDS.

Under the head of Western public-land States are grouped not only States but also five Territories—Arizona, Indian Territory, New Mexico, Oklahoma, and Utah. In this category are included North Dakota, South Dakota, Nebraska, and Kansas; for although the eastern ends of these lie well within the humid region and project into the eastern part of the United States, yet the vacant public lands of these States are for the most part in their western halves, and are all either arid or semiarid in character, and therefore, for purposes of discussion, they may be considered as belonging to the arid part of the country. Texas, also, would be included in this division but for the fact, as previously stated, that this State, coming into the Union as an independent Republic, retained possession of its own lands, most of which have been disposed of according to land laws and a system peculiar to the State.

Total land surface, area disposed of, reserved, and vacant in Western public-land States.

States. a	Land surface. b	Area disposed of.		Area reserved.		Area vacant.	
	Sq. miles.	*Sq. miles.*	*Per ct.*	*Sq. miles.*	*Per ct.*	*Sq. miles.*	*Per ct.*
Arizona	112,920	6,634	5.87	20,378	18.05	85,908	76.08
California	155,980	56,445	36.19	9,320	5.98	90,215	57.83
Colorado	103,645	30,104	29.04	6,607	6.38	66,934	64.58
Idaho	84,290	5,708	6.77	3,483	4.13	75,099	89.10
Indian Territory	31,000	.....	.....	31,000	100	.....	.....
Kansas	81,700	80,410	98.42	150	.18	1,140	1.40
Montana	145,310	16,196	11.14	15,057	10.37	114,057	78.49
Nebraska	76,840	59,358	77.25	296	.39	17,186	22.36
Nevada	109,740	3,906	3.55	1,263	1.15	104,571	95.30
New Mexico	122,460	29,688	24.24	7,470	6.10	85,302	69.66
North Dakota	70,195	30,169	42.98	6,936	9.88	33,090	47.14
Oklahoma	38,830	12,302	31.68	11,315	29.14	15,213	39.18
Oregon	94,560	28,581	30.23	10,092	10.67	55,887	59.10
South Dakota	76,850	35,695	46.45	15,951	20.76	25,204	32.79
Utah	82,190	7,812	9.51	7,070	8.60	67,308	81.89
Washington	66,880	26,257	39.26	7,866	11.76	32,757	48.98
Wyoming	97,575	6,051	6.20	7,880	8.08	83,644	85.72
Total	1,550,965	435,316	28.07	162,134	10.45	953,515	61.48

a Including five Territories.
b Area as given by Henry Gannett in Bulletin No. 23 of the Eleventh Census.

The relative areas vacant, reserved, and disposed of, given in the above table, are graphically exhibited in the accompanying diagram, fig. 49. In this the length of each horizontal bar indicates the total area of the State or Territory; the uncolored part designates the area now vacant; the diagonally lined portion represents the area reserved (much of which will ultimately be thrown open to settlement), and the black part shows the extent to which the land has passed out of the hands of the National Government. As shown by this diagram, the greatest amount of vacant public land is in Montana, where there are over 114,000 square miles still open. The greatest proportion, however, is in Nevada, where, according to the estimates, over 95 per cent of the total area is still at the disposal of Congress. Next to Montana and Nevada, in the order of extent of vacant lands, is California, with over 90,000 square miles, this being, however, a little more than one-half the total area of the State. Next come Wyoming and New Mexico, each having about the same amount of vacant land.

The smallest area of vacant public land in any Western State is in Kansas, where the amount still in the hands of the National Government is less than 2 per cent. This State, if consideration is had only of the area of its public lands, hardly belongs in this category, but should be classified with Iowa and other of the States east of the center of the country. The disposal of the lands in the western end of the State was, however, largely the result of misapprehension of their character, and was due to a series of waves of popular excitement, or "booms," by which settlers were induced to locate where many of them have since found it impossible to make a living. As a consequence, although the National Government has parted with thousands and even millions of acres of this Western land, yet to all intents and purposes it is still vacant and unutilized.

Next above Kansas, in order of area of vacant land, comes Oklahoma, with an estimated area of about 15,000 square miles, mainly in the western portion of that Territory and in the long strip of Beaver County, often designated "No Man's Land." This country is similar in character to western Kansas and eastern Colorado, being unsuitable for settlement except at the relatively few points where water can be had. It is, however, admirably adapted to grazing, and must ultimately

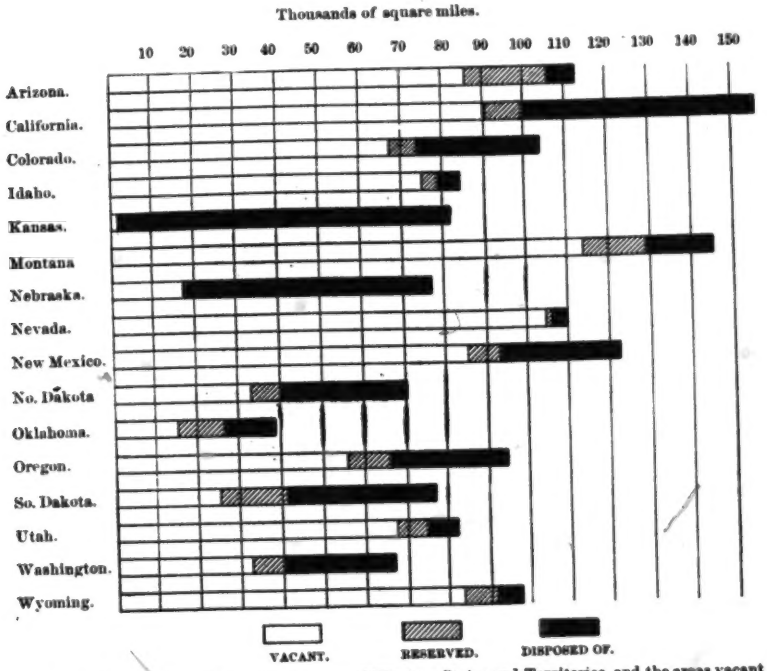


FIG. 49.—Diagram illustrating relative areas of Western States and Territories, and the areas vacant, reserved, and disposed of.

be used largely for this purpose. Nebraska, with about 17,000 square miles, comes next, its vacant land, as shown by the map, being also mainly in the western end and north of the Platte River.

GENERAL CHARACTER OF THE LANDS.

Before discussing the lands disposed of, reserved, and vacant, and their water supply, it is essential to have a clear conception of the physical characteristics of the Western public-land States as a whole. This part of the country embraces a wider range of climatic and topographic conditions than that of the Eastern part. It includes vast mountain ranges whose summits are perpetually covered with snow, and broad, almost impassable deserts, alternately burned by a semitropical sun or

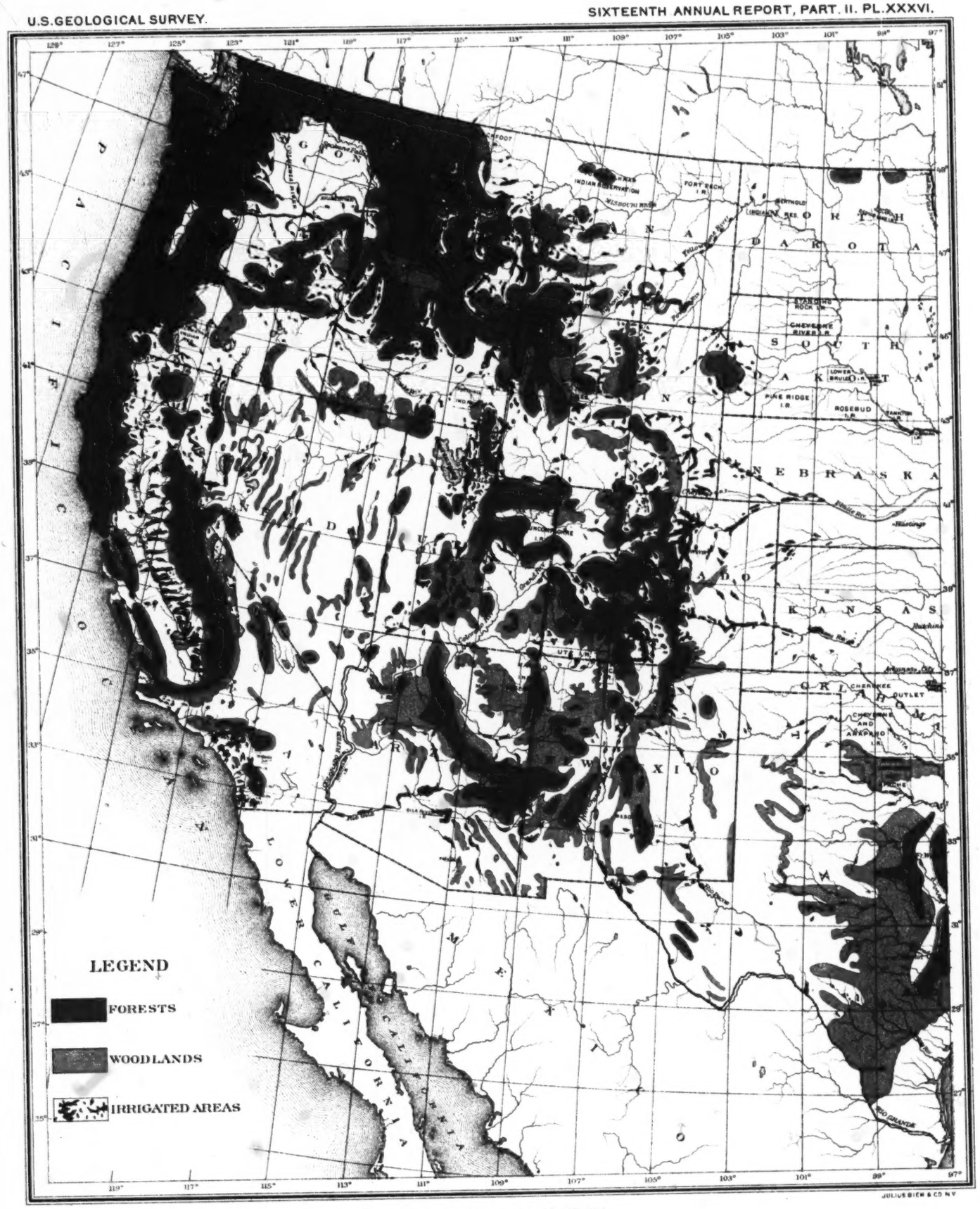
chilled by arctic blasts. On the east are boundless prairies and plains, gradually rising to the plateau upon which stand the Rocky Mountains, these treeless regions at times clothed with luxuriant vegetation and again parched with seemingly endless drought. West of the Rocky Mountains is the broad Interior Basin, from which no waters escape to the sea—a region of intense sunshine and extreme drought. This is a land of precipitous mountains, whose bases are surrounded and buried by valley deposits level as a floor, showing unmistakable evidence of the comparatively recent existence of extensive bodies of water. On the west rise the great ranges of the Sierra Nevada and Cascade, their summits piercing the clouds and drawing from them the waters which, in the form of rivers, furrow the steep slopes. Beyond these are the valleys of the Pacific Slope, with their wonderfully fertile soil, and between them and the ocean are the irregular coast ranges, forming rocky and often inhospitable shores. On the south is a warm, almost tropical climate, suitable to the development, under high cultivation, of many of the most valuable fruits; and toward the north are colder, more rigorous conditions, favorable to the growth of cereals.

The greater part of the surface of these Western public-land States is well known to be arid—that is, the precipitation in the form of rain or snow does not occur in sufficient quantities or at the right times to render profitable the cultivation of the ordinary crops. It is not possible in this general review to enter into the details of the rainfall and of its time of occurrence; that subject has been presented more completely in various reports of the Signal Service, of the Weather Bureau, and of this Survey.[1]

Although the country as a whole is arid, yet there are considerable areas, especially on the high mountains, at one time covered by forests, and in scattered localities well within the arid region, where crops are often raised without irrigation. By far the larger proportion of the surface supports a great number and variety of plants adapted to withstand drought, many of the grasses being of high value for grazing. Although scanty, the herbage is usually sufficient to furnish food for flocks or herds, and the arid region as a whole may be considered as a great grazing land, with occasional desert areas, and, more rarely, with spots where, under careful cultivation, fair crops can be produced, or where, through unusual precipitation, trees have obtained a foothold. The soil, especially that of the plains and broad valleys, is of great fertility, having been exposed for countless years to the disintegrating influences of the weather, and its material suitable for plant food not having been drawn upon to any considerable extent.

The accompanying map (Pl. XXXVI) exhibits the relative position of the wooded areas and grazing and irrigated lands west of the ninety-

[1] Thirteenth Annual Report United States Geological Survey, Part 3, Irrigation, p. 27; Fourteenth Annual Report United States Geological Survey, p. 152, Plate VI. The first of these reports gives a diagram of the mean monthly distribution of precipitation at various points in the West, and the second, by means of a map, shows the mean annual distribution over the whole country.



RELATIVE LOCATION OF

FORESTS, WOODLANDS AND IRRIGATED AREAS

IN THE

WESTERN PART OF THE UNITED STATES

By F. H. NEWELL.

Scale.

100 0 100 200 300 400 500 Miles

1895.

seventh meridian. On the map the wooded portions are divided into two classes—districts in which a considerable number of trees are suitable for timber, colored dark green, and districts in which the greater part of the growth is scattering or is so small that the wood is valuable only for fuel, fence posts, or occasionally for mine props. Areas of this latter character are denoted on the map by a sage color. They are seen to fringe to a great extent the forested areas and to cap

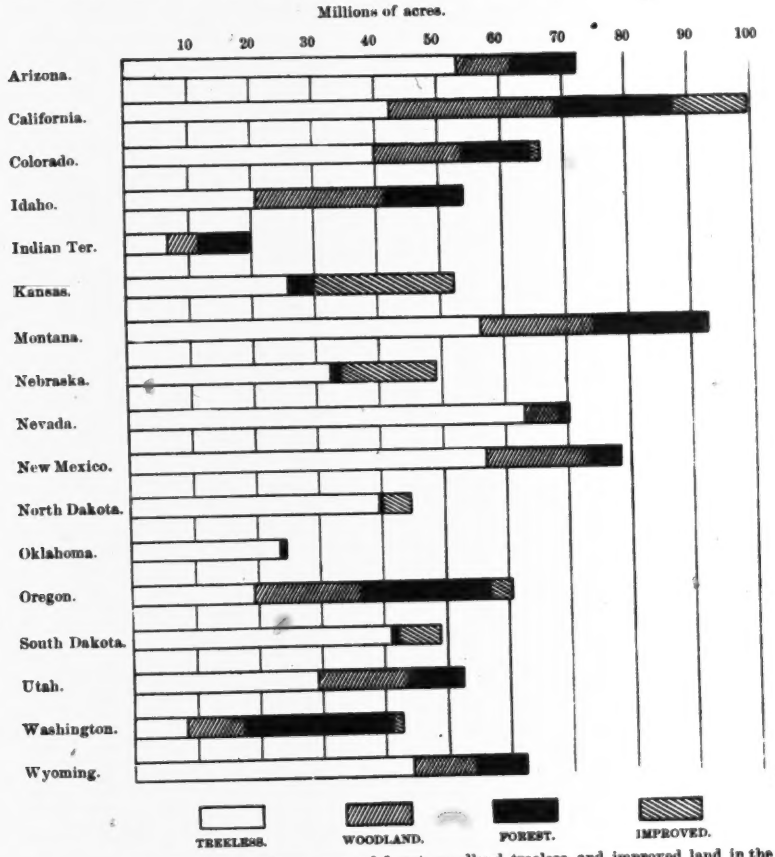


FIG. 50.—Diagram illustrating relative areas of forest, woodland, treeless, and improved land in the Western States.

the mountains or broad plateaus where a heavier growth has not been possible. The uncolored portions of the map represent for the most part the great body of the grazing lands, while the red spots show the location of the areas irrigated. A map of woodlands, similar to this and prepared from the same data, has been published by Mr. B. E. Fernow, Chief of the Division of Forestry, in the report of the Secretary of Agriculture for 1893, page 317.

An estimate of the areas of forest and small trees, and of open or treeless areas, has been prepared, giving in round numbers the probable extent of these various classes of lands. These figures relate to climatic and soil conditions favorable to forest and tree growth rather than to existing forests as partly destroyed by artificial agencies. In many cases vast tracts have been burned over, injuring the merchantable timber, but Nature will do her part in restoring the growth if the young trees are protected from fire, cattle, and sheep. There is need of more accurate information in regard to the extent and value of the natural woodlands of the West, the matter being one concerning which many contradictory opinions have been held, and very little accurate knowledge is obtainable. The figures submitted, however, are believed to be as nearly correct as they can be made at the present time, although in detail they may be subject to considerable criticism.

The following table gives, in acres, the land surface of each State and Territory, and, in round numbers, the estimated area originally covered by forest and by scattered trees, here designated as woodland. The discrimination between forest and woodland is of course largely a matter of personal opinion, as the one shades into the other, and trees which in one locality are regarded as useless are of considerable value in another, where timber is scarce. After these is shown the extent of the treeless or open country, this being the remainder after deducting the forest, woodland, and improved areas. The last column shows the number of acres of improved land, as published by the census for 1890. These facts are shown in graphic form in fig. 50, page 481.

Forest, woodland, treeless, and improved areas in Western public-land States.

States and Territories.	Land surface.	Forest. *a*	Woodland.	Treeless.	Improved. *b*
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Arizona	72,268,800	10,000,000	8,700,000	53,464,672	104,128
California	99,827,200	18,000,000	27,000,000	42,604,361	12,222,839
Colorado	66,332,800	10,600,000	14,000,000	39,909,280	1,823,520
Idaho	53,945,600	10,800,000	21,600,000	20,939,238	606,362
Indian Territory	19,840,000	8,000,000	5,000,000	6,840,000	.....
Kansas	52,288,000	4,000,000	.....	25,984,699	22,303,301
Montana	92,998,400	17,000,000	18,600,000	56,482,883	915,517
Nebraska	49,177,600	1,500,000	.....	32,429,895	15,247,705
Nevada	70,233,600	1,000,000	5,300,000	63,210,548	723,052
New Mexico	78,374,400	4,700,000	16,500,000	56,911,294	263,106
North Dakota	44,924,800	400,000	.....	39,866,785	4,658,015
Oklahoma	24,851,200	500,000	.....	23,787,472	563,728
Oregon	60,518,400	20,600,000	17,000,000	19,402,400	3,516,000
South Dakota	49,184,000	1,000,000	.....	41,224,707	6,959,293
Utah	52,601,600	8,400,000	14,200,000	29,453,377	548,223
Washington	42,803,200	23,500,000	9,000,000	8,482,368	1,820,832
Wyoming	62,448,000	7,500,000	10,000,000	44,471,169	476,831
Total	992,617,600	147,500,000	166,900,000	605,465,148	72,752,452
Per cent	100	14.86	16.81	61	7.33

a Report of the Secretary of Agriculture for 1893, pp. 317, 318.
b Abstract of the Eleventh Census 1890, Washington, 1894, pp. 62, 63.

A second estimate has been prepared to show, in round numbers, the extent of grazing, wooded, forest, and desert areas within the arid and semiarid portions of the Western public-land States. In preparing this

the figures previously given have been used, selection being made somewhat arbitrarily of those portions of the States of Washington, Oregon, and California which may be considered as humid. The table shows, therefore, the relative proportion of these four classes of land in each of the States and Territories, and exhibits in a general way the natural resources of the various divisions of the regions where water is of prime importance.

Grazing, woodland, forest, and desert areas within the arid and semiarid portions of the Western public-land States.

States and Territories.	Grazing.	Wooded.	Forest.	Desert.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Arizona	38,000,000	8,700,000	10,000,000	15,000,000
California	20,000,000	6,000,000	4,000,000	20,000,000
Colorado	40,000,000	14,000,000	10,600,000	
Idaho	20,000,000	19,000,000	8,000,000	
Kansas	15,000,000			
Montana	56,000,000	15,000,000	15,000,000	
Nebraska	25,000,000			
Nevada	43,000,000	5,300,000	1,000,000	20,000,000
New Mexico	57,000,000	16,500,000	4,700,000	
North Dakota	25,000,000			
Oklahoma	20,000,000			
Oregon	15,000,000	7,000,000	4,000,000	
South Dakota	30,000,000		500,000	
Utah	20,000,000	14,200,000	8,400,000	10,000,000
Washington	8,000,000	3,000,000	2,000,000	
Wyoming	39,000,000	10,000,000	7,500,000	5,000,000
Total	471,000,000	118,700,000	75,700,000	70,000,000

Grazing lands.—As shown by the table on page 482, over 600,000,000 acres, or more than three-fifths of the entire area of the Western public-land States, consists of open, treeless country. Although there is not a sufficient supply of moisture to support or encourage the growth of trees upon the greater part of this vast area, yet almost everywhere herbage of one kind or another has succeeded in obtaining a foothold, and during portions of the year, at least, furnishes excellent grazing. The soil of this country is usually very fertile, but the investigations of water supply have shown that it is highly improbable that a sufficient quantity of water can ever be obtained to reclaim more than a very small percentage of these arable lands. The greater part must always remain uncultivated, except in so far as plants adapted to arid conditions may be introduced.

The great bulk of the area of the Western public-land States as a whole consists of grazing lands, and it may truly be said that one of the greatest problems, upon whose solution the prosperity of the West depends, is the wise and efficient control of the grazing industries. As previously stated, all of the vacant public lands are open, and can be grazed over by the flocks and herds of any person. With free pasturage, the sheep and cattle business has in the past been one of enormous profits. The natural increase being rapid, comparatively small capital was required at the outset. Herds raised in one State or Territory are driven hundreds, and even thousands, of miles to and fro across the public domain, going north in summer and south in winter,

or from remote portions of the West nearer to the markets of the East. As a result of the large profits obtained in the past, herds of cattle and flocks of sheep have been allowed to increase to such an extent that the free ranges, including both woodland and treeless areas, although embracing almost one-half of the United States, have been overstocked, and many of the valuable native grasses have been eaten down so closely by the sheep, or so trampled underfoot, that it is reported that over vast extents of country not a single useful plant can now be found.

The settler, with his small herd out on the vast tract of the public domain, may try to preserve some of the valuable grazing lands about him; but the wandering cattleman, or worse, the sheepman with his flocks numbering thousands, may at any time pass over the country, and in a few days, or even hours, the ground is as bare as though blasted by years of drought. Permanency of occupation is thus discouraged, and the nomadic life, with its accompaniment of lawlessness and indifference to the future and to the public good, is forced upon the pioneer.

Wooded areas.—On the map, Pl. XXXVI, an attempt has been made to divide the wooded areas into two groups, those on which trees of sufficient size to furnish merchantable timber have grown, and those where the natural conditions are such that the trees are so small or scattering as to be useful only for firewood, fence posts, or mining purposes. The former area includes the great forests of the West, these being found mainly upon the high, rocky slopes of the Sierra Nevada, Cascade, and Coast Ranges, where, under favorable climatic conditions, some of the largest and most valuable timber of the country is grown. These forest areas, colored green, are shown also as extending along the ranges of northern Idaho and western Montana and the irregular mountain masses of Utah, Colorado, Arizona, and New Mexico. Many tree-covered areas in the Rocky Mountain region have been designated forests, although the size and character of the trees are such that if they were in California or western Oregon they would be considered as fit only for fuel. The scarcity of timber and the demand for anything that can be cut into merchantable size causes trees which would be considered worthless in one part of the country to be cut and manufactured into lumber in another.

The term "woodland" has been used in the table to designate those areas where the trees or large shrubs, although of no especial value for timber, furnish firewood and material for the construction of fences and of shelter for cattle, and thus supply some of the needs of the settler. It also includes considerable areas of small trees, sufficiently large to be used as props in mines, and even the growths or thickets of dwarfed oaks and the larger growth of bushes classed by the frontiersmen under the general term "chaparral." As a rule, it may be said that where these scattering trees are found there is excellent grazing among them; and therefore, although this area of nearly 167,000,000 acres is classed as woodland, it has a hardly less value for grazing purposes.

Desert lands.—The area of land which is desert and probably worthless has been found in the progress of settlement to be relatively small. Before the West was thoroughly explored and well known it was generally considered that the greater part was absolutely valueless, but with the introduction of irrigation and of methods of agriculture suited to the climate, with the provision of water for cattle, and especially with the facilities for rapid transportation, it has been found possible to utilize for cultivation or grazing nearly all the lands which were previously considered barren and rocky wastes.

It is of course impossible to discriminate with any degree of exactness between lands which at one time or another support for a few weeks or months a scanty growth sufficient for grazing purposes, and those which are at all times so barren that cattle can not find means of sustenance. It has been estimated, however, that there are in all about 70,000,000 acres of such desert lands (p. 483). Of this, 15,000,000 acres are in southern and southwestern Arizona; 20,000,000 acres are in southern California, north and east of the San Bernardino Mountains and adjacent to Nevada and Arizona; 20,000,000 acres are in southern and eastern Nevada; 10,000,000 acres are in Utah, west of Great Salt Lake; and 5,000,000 acres are in Wyoming, in the southwestern portion, near the head of Green River.

Improved and irrigated lands.—The table on page 482 shows that out of the entire extent of the Western public-land States only about 72,752,452 acres, or 7.33 per cent, was improved at the time of the Eleventh Census, in 1890. Of this the greater part was in Kansas, Nebraska, and the Dakotas, leaving only 23,584,138 acres in the States and Territories within the arid region. A large portion of this improved land, especially in California, Oregon, and Washington, lies within the strip of humid country adjacent to the Pacific Coast. Making due allowance for this, it has been estimated that only between 1 and 2 per cent of the arid region can be designated as improved.

The area actually cultivated is far less than the amount above given, and the extent redeemed by irrigation is relatively insignificant. According to the last census there were in the arid and subhumid lands only 3,631,381 acres irrigated, this being about one-half of 1 per cent of the area of the States within which irrigation was largely practiced. Since 1890 there has been a considerable extension of the area cultivated by the artificial application of water, but concerning this there are no reliable figures. Owing to the depressed industrial condition of the West during 1893, 1894, and 1895, it is highly improbable that more than double this amount was actually cultivated in this manner, although claims are made that considerably larger acreages were covered with water. Making liberal allowances, it is estimated that not more than 1 per cent of the arid lands is now irrigated and tilled.

It is not generally appreciated that a considerable area of land, even within the borders of the arid region, is cultivated each year by what

is there known as "dry farming." By taking advantage of local conditions of rainfall, by thorough cultivation, and by the selection of crops which withstand a considerable drought or which mature before the extreme heat of the year is felt, it has been found possible to obtain profitable crops in a few localities in each arid State. The production per acre is usually small, but it is possible to compensate for this low average value by tilling large areas of the fertile, easily worked soil. The accompanying map (fig. 51) is intended to show in a general way

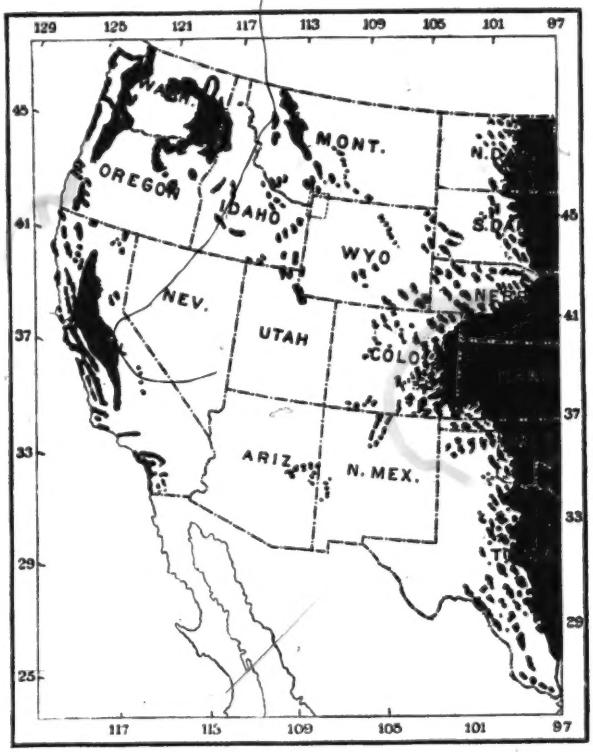


FIG. 51.—Areas within which dry farming is attempted.

by the groups of black dots the lands upon which crops have been raised occasionally without the artificial application of water. On the east the solid black indicates the debatable ground between the region in which irrigation is not considered necessary and that which is known to be too arid for successful agriculture without irrigation. The area within which "dry farming" is occasionally successful is seen to extend across Kansas and into eastern Colorado, following the divide between the Platte and Arkansas drainage as far west as the foothills of the Rocky Mountains. All through this country fair crops have occasionally been

obtained, but as a rule the farmers can not be said to be successful, the results of a fortunate year not compensating for continued losses at other times.

Along the Rocky Mountain region from western Montana southerly through northern Utah[1] to the high plateaus of Arizona are occasional spots where, within or near the wooded lands, farmers plant grain, potatoes, and sometimes other crops with a fair degree of success. There is little, however, to recommend dry farming, except the fact that occasionally something can be raised in this manner, and it is usually impossible at these high altitudes, with the means at hand, to obtain water. Farther west, in eastern Washington and northern Oregon, are considerable tracts bordering the Blue Mountains and the ranges of northern Idaho in which dry farming is attempted. The structure of the soil is such that the supply of moisture received, although apparently scanty, suffices to produce large crops of cereals, and these lands, while considered well within the arid region, are noted for their productiveness. The remaining areas of black spots near or parallel to the Pacific Coast represent the lands cultivated in the valleys west of the Cascade and Sierra Nevada ranges. These, as a rule, receive considerable rainfall except during the latter part of the summer season, but in the case of the southern part of the San Joaquin Valley the precipitation is very slight, and dry farming on a large scale is being replaced by the irrigation of small tracts.

LANDS DISPOSED OF.

As shown by a preceding table (p. 478), the lands disposed of in the Western public-land States have been estimated at 278,602,289 acres, or 435,316 square miles, this being a trifle over 28 per cent of the total area of these States and Territories. This estimate has been prepared from the reports of the General Land Office.[2]

In the following table these lands have been divided into three classes—those disposed of to railroad corporations as an inducement or aid to the original construction of the railroads, the swamp lands granted to the States, and private and miscellaneous disposals, for the most part to individuals for homes.

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[1] Report on Agriculture by Irrigation in the Western Part of the United States at the Eleventh Census, 1890, F. H. Newell, Washington, 1894, p. 222.

[2] Annual Report of the Commissioner of the General Land Office for the fiscal year ending June 30, 1894, pp. 288, 304, 321.

Lands disposed of in Western public-land States.

States and Territories.	Railroad.	Grant and swamp.	Private and miscellaneous.	Total disposed of.	
				Acres.	Square miles.
	Acres.	*Acres.*	*Acres.*		
Arizona	1,751,401	.....	2,494,408	4,245,809	6,634
California	6,464,235	10,531,852	19,128,525	36,124,612	56,445
Colorado	638,924	1,404,000	17,223,549	19,266,473	30,104
Idaho	160,609	.....	3,492,613	3,653,222	5,708
Kansas	7,703,465	.....	43,758,742	51,462,207	80,410
Montana	5,027,280	.....	5,338,087	10,365,367	16,196
Nebraska	7,258,298	.....	30,730,972	37,989,270	59,358
Nevada	551,647	.....	1,948,353	2,500,000	3,906
New Mexico	1,438,485	14,181,000	3,380,515	19,000,000	29,688
North Dakota	6,603,060	.....	12,704,853	19,307,913	30,169
Oklahoma	.....	.....	7,873,118	7,873,118	12,302
Oregon	2,667,401	217,998	15,406,410	18,291,809	28,581
South Dakota	.....	.....	22,844,814	22,844,814	35,695
Utah	747,124	.....	4,252,876	5,000,000	7,812
Washington	7,848,576	.....	8,956,191	16,804,767	26,257
Wyoming	758,125	.....	3,114,783	3,872,908	6,051
Total	49,618,630	26,334,850	202,648,809	278,602,289	435,316

Railroad lands.—The first column of the table, under the heading "Railroad," includes both the amount already patented to the railroad corporations and the area selected but to which the title has not yet been confirmed. These figures by no means represent the total extent of the grants by Congress to the various transcontinental lines. As shown by the general map, Pl. XXXV, these railroad lands extend in broad belts across the country, including some of the most valuable areas within the States traversed. The most northerly of these is the Northern Pacific. This grant, dated July 2, 1864, designated the line of the road as extending westerly by the most eligible route from a point on Lake Superior, in Minnesota or Wisconsin, to a point at or near Portland, Oregon. The odd sections, to the amount of 10 sections per mile on each side of the road in the States and 20 sections on each side of the road in the Territories, were granted. In case, however, title to these designated sections could not be given to the corporation, it was allowed to select an equivalent amount of land lying within 30 miles of the road in the States and within 50 miles in the Territories. On the map the grant lands are not shown east of the State of North Dakota, but to the west of the Red River they are indicated in a general way by crosshatching, covering an area 80 miles in width, within which every alternate section belongs to the railroad company or will ultimately become its property. The indemnity limits extending outside of this are not given.

Stretching across the central part of the country are the grant lands of the Union Pacific and of the Central Pacific Railroad companies, the first extending westerly from the Missouri River to Ogden, Utah, and the second from Ogden west to San Francisco. The original grant to the Union Pacific Railroad Company was dated July 1, 1862. It provided for the construction of a railroad from the western boundary of Iowa to a point on the one hundredth meridian within or

between the valleys of the Republican and Platte rivers, and from this point westesly to the western boundary of Nevada. Subsequent legislation granted the odd sections within 20 miles on each side of the road, but gave no indemnity limits. Branch lines were also provided for by subsequent grants to the same corporation or other companies which have later become parts of the Union Pacific system. The location of the alternate sections thus granted is shown on the map by the cross-lined portions in Nebraska, Wyoming, Colorado, and Kansas.

The most southerly grant is that to the Atlantic and Pacific Railroad Company, extending from a point near Albuquerque, N. Mex., westerly across Arizona. This was originally dated July 27, 1866, and called for the construction of a road from the States of Missouri and Arkansas to the Pacific Coast. Grants were made to this company of odd sections to the amount of 20 sections per mile on each side of the road through the Territories. By subsequent action, resulting from failure to complete this road through Indian Territory and eastern New Mexico, the grant was reduced to the limits above mentioned. The grants within the States of Missouri and Arkansas, as well as those of the other Eastern public-land States, are not shown upon the map, as upon this scale such representation would be confusing.

Extending in a general northerly-and-southerly direction through California and Oregon are the land grants of the Central or Southern Pacific Railroad. These have been represented upon the map as nearly as possible, although many important questions are still in dispute, and the exact extent and location of the railroad-grant lands can not be definitely known. The band upon the map indicates the belt of country 20 miles wide on each side of the road within which each odd-numbered section has been granted to this company. The indemnity limits, extending 30 miles on each side, are not shown. The Southern Pacific system includes the original grant to the Central Pacific, above mentioned, of odd sections within 20 miles on each side of the road extending from Ogden, Utah, to San Francisco, Cal., this possessing, however, no indemnity limits.

Within the State of Oregon are shown on the map three narrow bands indicating the location of lands granted for the construction of various wagon roads. The most northerly of these is that from The Dalles, in Oregon, to Fort Boise. The original grant was dated February 25, 1867, and donated the odd sections for 3 miles in width on each side of the road, with indemnity limits extending to the odd sections within 10 miles of the road. Immediately south of this is the road from Albany, Oregon, to the eastern boundary of the State, this embracing 3 sections per mile to be selected within the limits of 6 miles on each side of the road. The third notable wagon-road grant is that from Eugene, Oregon, to the eastern boundary of the State, including odd sections for 3 miles in width on each side of the road, without indemnity limits. There are a number of shorter wagon-road grants within this State extending from the valleys west of the Cascade Range to the coast.

The figures above given do not by any means indicate the total amount of land which will ultimately be patented to the railroad corporations or their representatives, but merely the amount which has already been selected and patented. There are still many millions of acres embraced within the grant limits which, although reserved on the books of the General Land Office, have not as yet been selected by the railroads. For purposes of taxation these lands are considered as public lands until taken by the railroad companies, and therefore, to avoid payment of taxes and other liabilities, it is apparently the custom of the railroad corporations to neglect to make selections until the land is disposed of or is of immediate use. So far as can be ascertained, no estimate has yet been made of the probable amount of these transcontinental railroad-grant lands, and there is considerable uncertainty regarding the status of large tracts, owing to unsettled questions as to whether portions of large donations have not been forfeited.

Grant and swamp lands.—Under this heading is included the estimated acreage within each of the public-land States claimed by individuals under the old Spanish grants or selected by the State under the swamp-land act. The greater part of this is within California, Colorado, and New Mexico, where the Spanish grants, aggregating many millions of acres, comprise some of the choicest lands. The principal area of so-called swamp lands is in the State of Oregon, where, under the construction of this act, a considerable extent of fertile land has been patented to the State. The figures do not include the amount selected, as it is improbable that all of this will be thus given away.

Private and miscellaneous entries.—The third column of figures in the table includes by far the greater portion of the land disposed of, and is intended to represent the amount which has been sold or patented under the preemption, homestead, desert, timber-culture, and similar acts. At this time it is not practicable to separate these different methods of disposing of the land, but from an inspection of the figures it appears that by far the greater portion of the land has been taken up under the homestead act, although many of the entries were later commuted for cash.

LANDS RESERVED.

The table on page 478 gives as the area reserved in the Western States 162,134 square miles, this being a little over 10 per cent of the aggregate extent of the Western States and Territories. This amount is made up principally of the Indian reservations, next in importance coming the large tracts reserved for the purpose of protecting the forests. To this have been added the military reservations. There are, in addition, tracts withheld from entry by various special acts of Congress or by decisions of the General Land Office. These, however, in the aggregate are relatively small and need not be considered in this connection.

Indian reservations.—The data as to the location and extent of the Indian reservations have been taken from the annual report of the Commissioner of Indian Affairs.[1] In this volume is given the area of each reservation in acres and in square miles, together with the name of the tribe occupying it. These areas are given by States and Territories in the following table, adjustment being made where a reservation extends across State lines. Besides the reservations embraced within the Western public-land States, given in the table on page 466 (including the military reservations), and in detail on page 492, there are others in the eastern half of the country aggregating 2,832,512 acres, or 4,426 square miles. This amount is made up as follows: Iowa, 2,900 acres; Michigan, 5,944; Minnesota, 2,243,753; New York, 87,677; North Carolina, 65,211; Wisconsin, 427,027. The lands reserved for Indian purposes in the West (82,708,797 acres) are being steadily diminished year by year, the lands being in many cases allotted in severalty to the Indians and the balance thrown open to settlement by the whites. A few years ago the Indian reservations appeared as extensive tracts covering a large part of the map of the United States, but now some of them can hardly be found, so greatly have their areas been reduced.

Forest reservations.—The reservation of land for the purpose of forest protection is a novel procedure in the administration of public lands, being somewhat in the nature of an experiment. The law under which these forest reservations are proclaimed by the President was approved on March 3, 1891, and since that time seventeen reservations have been proclaimed, having an aggregate area of 17,564,800 acres,[2] or 27,445 square miles. These reservations, as shown by the map, Pl. XXXV, are within the States of California, Colorado, Oregon, Washington, and Wyoming, and the Territory of Arizona. With these is here included the Yellowstone National Park (1,920,000 acres, mainly in Wyoming), which, although reserved as a park, can in effect be classified most nearly with these forest reservations. No reservation of this character has been made by the National Government in the eastern part of the United States, but comparable to these forest reservations are the great State parks instituted by New York. It is probable that in order to protect the water supply of densely populated areas many of the older States will be compelled to purchase and hold considerable tracts of rough or mountainous land, unfit for agriculture. These lands, if protected from fire, and, if necessary, supplied with desirable kinds of trees, will be of value, not only as furnishing unpolluted waters, but as supplying timber as rapidly as the trees reach maturity.

Military reservations.—The lands now held for military purposes are enumerated in the annual reports of the Commissioner of the General Land Office. In the volume for 1894 these are given on pages 247–255.

[1] Report of the Commissioner of Indian Affairs, 1894, pp. 484–498.

[2] Report of the Commissioner of the General Land Office, 1894, p. 43.

According to this statement, the total extent is 1,597,933 acres, or 2,497 square miles. Of this amount, nearly the entire extent is in the Western public-land States, 26,019 acres only being in the the eastern part of the country. Of this, about 14,000 acres are in Florida, the remainder being included within the States of Alabama, Arkansas, Illinois, Louisiana, Michigan, Minnesota, Missouri, and Wisconsin. These military reservations are being abandoned from time to time, and although not at present open to settlement, yet they might be considered as part of the vacant public lands.

Reservations in Western States.

States and Territories.	Indian.	Forest.	Military.	Total.	
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Sq. miles.*
Arizona	a 11,051,507	1,851,520	139,149	13,042,266	20,378
California	438,868	5,438,720	87,469	5,965,057	9,320
Colorado	1,094,400	3,103,360	30,720	4,228,480	6,607
Idaho	b 2,225,051	.....	3,796	2,228,847	3,483
Indian Territory	19,840,000	.....	.....	19,840,000	31,000
Kansas	73,796	.....	22,649	96,445	150
Montana	9,382,400	.....	253,824	9,636,224	15,057
Nebraska	127,433	.....	61,995	189,428	296
Nevada	b 808,215	.....	.....	808,215	1,263
New Mexico	a 4,300,085	311,040	169,492	4,780,617	7,470
North Dakota	3,812,833	.....	625,899	4,438,732	6,936
Oklahoma	7,208,738	.....	32,640	7,241,378	11,315
Oregon	1,803,495	4,653,440	1,945	6,458,880	10,092
South Dakota	10,168,842	.....	39,985	10,208,827	15,951
Utah	a 4,516,480	.....	8,148	4,524,628	7,070
Washington	4,046,564	967,680	19,825	5,034,069	7,865
Wyoming	1,810,000	c 3,159,040	74,378	5,043,418	7,880
Total acres	82,708,797	19,484,800	1,571,914	103,765,511	.....
Total square miles	129,233	30,445	2,456	162,134	162,134

a The total area of the Navajo Indian Reservation is given in the report of the Commissioner of Indian Affairs for 1894 (p. 490) as 7,698,560 acres, and as being in the Territory of New Mexico. This reservation is, however, mainly in Arizona, and extends northward into Utah. An estimate of the amount of land in each Territory gives the following figures: Arizona, 4,651,560 acres; New Mexico, 2,503,000 acres; Utah, 544,000 acres; total, 7,698,560 acres. These figures have been added to the area of reservations in Utah and Arizona, respectively, as given in the report of the Commissioner of Indian Affairs, and corresponding deduction has been made from the total extent of Indian reservations in New Mexico.

b The Duck Valley Indian Reservation is given as being in Nevada, but nearly one-half of it extends northward into Idaho. An estimate of the amount in each State gives in Idaho 145,920 acres, and this amount has been transferred to that State, a corresponding reduction being made in the figures of Indian reservations in Nevada.

c This amount includes 1,920,000 acres, the estimated area of Yellowstone National Park. This is considered as being wholly within the State of Wyoming, although the northern and western edges extend into Montana and Idaho.

VACANT LANDS.

The total extent of vacant lands in the Western States, as shown on page 478, is 953,515 square miles, or 610,249,600 acres, this being 61.48 per cent of the entire land surface of the seventeen States and Territories included under this designation. The general character of these lands has been already described, and their location can be seen by reference to the map, Pl. XXXV. As shown on this map, there is in in no State any very considerable area relative to its size that does not contain small patches of land which has passed out of the hands of the General Government. The otherwise colorless portion of the map which represents the broad expanse of arid land is broken here and there with dots representing localities where, from the occurrence of water, farmers or cattle men have found it possible to make a home.

Probably the largest extent of territory which might be carved out, free from occupation or private ownership, is the tract beginning west of Great Salt Lake and extending westward across Nevada and southward to southern California and western Arizona, and including the greater part of the really desert areas of the United States. This is bounded on the north by the grant lands of the Central Pacific Railroad, and is crossed on the south by the Atlantic and Pacific Railroad lands, but neither of these railroads has made any considerable selec-

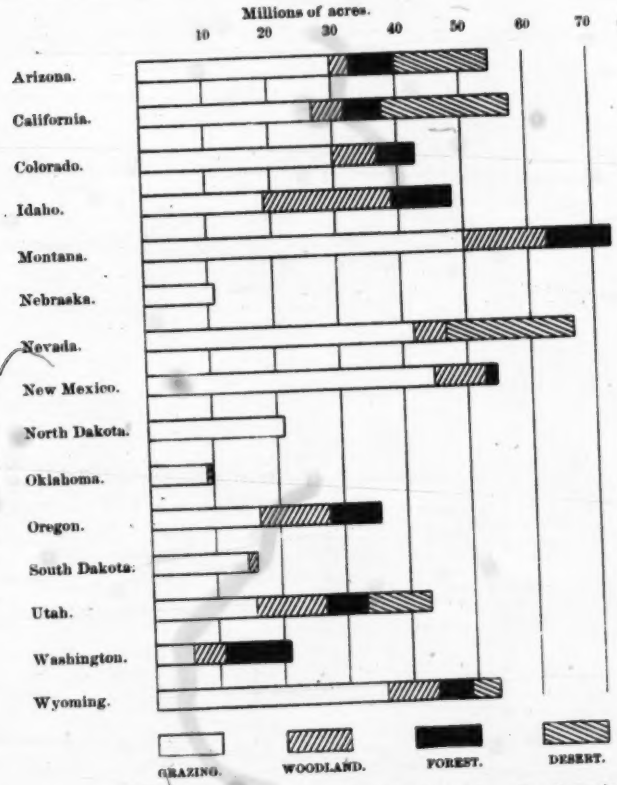


FIG. 52.—Diagram illustrating proportion of vacant lands, classified according to grazing, woodland, forest, and desert areas.

tions within these limits. The farms or ranches within this area are located at or near springs along the base of the mountains, and are at long distances from one another. The population is probably tending to diminish rather than to increase, owing to the lessened profits of cattle raising and decreasing demand for agricultural products.

The small map, Pl. XXXVI, exhibits in a broad way the relative proportion of grazing land, forest, and woodland. An estimate has been

prepared showing in round numbers the extent of lands of these classes now vacant, and also of the desert. This is comparable with the estimate shown on page 483, the latter, however, applying to the whole extent of the arid region, while this table relates only to the land now vacant and still owned by the General Government. It is, of course, impossible to arrive at any considerable degree of accuracy in such estimates, but the following figures are presented in order to bring clearly to mind the probable character of the unoccupied lands. The proportion of woodland and forest is notably large—greater than is generally supposed—but it must be borne in mind that on these areas the trees are very often very sparsely scattered, and that within the bounds considered as forest there are broad open spaces. The relative proportion of lands of these classes is shown on page 493 in diagram (fig. 52).

Vacant lands in the Western public-land States.

States and Territories.	Vacant.		Millions of acres.				
	Square miles.	Acres.	Grazing.	Wood.	Forest.	Desert.	Water supply.
Arizona	85,908	54,981,120	30	3	7	15	2
California	90,215	57,737,600	27	5	6	19	17
Colorado	66,934	42,837,760	30	7	6	0	8
Idaho	75,099	48,063,360	19	20	8	0	1.5
Montana	114,057	72,996,480	50	13	10	0	11
Nebraska	17,186	10,999,040	11	0	0	0	1.5
Nevada	104,571	66,925,440	42	5	0	20	2
New Mexico	85,302	54,593,280	45	8	2	0	4
North Dakota	33,090	21,177,600	21	0	0	0	2
Oklahoma	15,213	9,736,320	9	0	0	0	1
Oregon	55,887	35,767,680	17	11	9	0	3
South Dakota	25,204	16,130,560	15	0	1	0	5
Utah	67,308	43,077,120	16	11	6	10	4
Washington	32,757	20,964,480	6	5	10	0	3
Wyoming	83,644	53,532,160	36	8	5	5	9
Total	952,375	609,520,000	374	96	70	69	74

RATE OF DISPOSAL OF VACANT PUBLIC LANDS IN THE WESTERN STATES.

In order to exhibit the rate at which public lands are being disposed of, and to give some conception of the relation which the lands passing out of the hands of the General Government bear to the total amount still available, the table on page 496 has been prepared. This gives in square miles the average amount annually disposed of for the past five years. This quantity is compared with the total area of the State or Territory, and also with the total area now vacant. In nearly all cases the rate of disposal is less than 2 per cent per annum, the exceptions being in Oklahoma, where, owing to the throwing open of the Indian lands, there was an extraordinary increase of the number of entries. The average for all these sixteen States and Territories was almost exactly 1 per cent; in other words, at the rate of the last five years, an area equal to that of the whole of the sixteen Western States and Territories would be disposed of in one hundred years. In comparison with

the land now vacant, the rate of disposal has been 1.59 per cent, and if this rate should be maintained continuously until all of the lands had passed out of the hands of the National Government, it would require nearly sixty-three years to exhaust the present supply. As a matter of fact, however, as pointed out in the case of the Eastern public-land

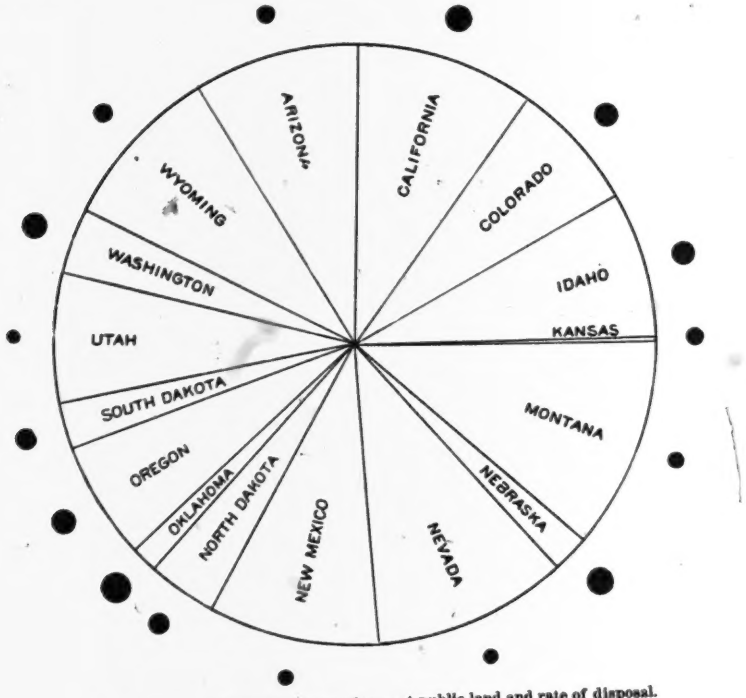


FIG. 53.—Diagram illustrating area of vacant public land and rate of disposal.

States, the rate of disposal is tending to decrease as the better lands are selected, so that this period would be indefinitely prolonged. A large part of this vacant land is also unsuitable for this private use, being desert in character, as has been shown, and under the present laws would remain forever in the possession of the National Government.

Rate of disposal of vacant public lands in the Western public-land States.

	Square miles.	Per cent of area of State.	Per cent of area vacant.
Arizona	544	.48	.63
California	1,556	1	1.72
Colorado	1,236	1.19	1.85
Idaho	486	.58	.65
Kansas	841	1.02	65.30
Montana	797	.55	1.68
Nebraska	1,612	.21	9.41
Nevada	131	.12	.13
New Mexico	501	.41	.59
North Dakota	858	1.22	2.59
Oklahoma	2,373	6.11	15.59
Oregon	1,075	1.13	1.84
South Dakota	1,200	1.56	4.76
Utah	325	.39	.48
Washington	1,254	1.88	3.83
Wyoming	513	.53	.59
Total	15,302	1.01	1.59

The rate of disposal is best exhibited by the diagram on page 495 (fig. 53). The large circle shows the total area of vacant land in the sixteen States and Territories, the segments being proportional to the land in each. The small dots around the edge exhibit the average amount of land being disposed of each year, and allow comparison with the total extent of the lands from which these disposals are made.

WATER SUPPLY.

SOURCES OF SUPPLY.

In the preceding pages has been given a general outline of the extent, location, and condition of the vacant public land and its relation to other portions of the country. It has been stated that the future utilization of this vacant land depends largely upon the water supply, and upon intelligent regulation thereof based upon a thorough knowledge of the resources of the country and its limitations in this regard. In the following pages it is purposed to give a brief statement of what is known of the available supply in each of the Western public-land States in which there are considerable areas vacant, and to indicate the lines of investigation now being carried on.

The sources of supply for the lands under discussion may be considered broadly under three heads—streams, wells, and stored water. By far the most important of these sources are the surface streams, since these furnish the greater part of the water and render valuable more than nine-tenths of the land now reclaimed by the artificial application of water. Wells, both artesian and of the ordinary form from which water is pumped, come second in importance, and reservoirs, or similar means of storing floods, come last, although in many instances of great value.

Streams.—In the discussion of streams as a source of water supply, it is convenient to distinguish between large and small, although there is, of course, no sharp line of demarcation between these. There are

very few really large rivers in the West, most of the streams containing a quantity of water so small that in humid regions the term "river" would not be used. The smaller streams—those commonly known as creeks—are fairly well distributed throughout the mountain region, and up to the present time have been of the first importance in the development of the country. The rivers carrying large volumes of water have not been sources of wealth in proportion to their size.

The smaller streams rising in the high ground descend with considerable fall, and the quantity of water throughout the larger part of the year being not greater than the capacity of a few ordinary irrigating ditches, it can be controlled by comparatively simple works. The steep grades of the stream beds make it possible for farmers or small communities to construct crude canals and carry the water far out upon the valley lands. On the other hand, the larger rivers, having usually less fall, except in narrow, rocky canyons, can not be controlled, nor can their waters be diverted without the most expensive construction. It is rarely possible for individuals, singly or in small groups, to dig ditches leading from these streams to the fertile soil, owing to the depth to which most of the rivers have excavated their channels below the adjacent flood plains or bench lands. The expense of construction and of maintenance increases geometrically as the size of the river increases, until, under pioneer conditions, with small resources beyond manual labor, and with uncertain future, it becomes almost impossible for settlers to introduce agriculture upon the fertile lands bordering the larger rivers. Thus it is that the greater part of the public domain in the Western States which has been taken up by individuals is along or near the small mountain streams, and developments have not proceeded rapidly along the larger rivers except upon the lower, humid plains. One reason for this is that throughout the great central portion of the Western States many of the important rivers have cut deep canyons and flow in narrow gorges; but even where the topographic conditions are such that water might be taken out, the enormous expenditure necessary has been prohibitory.

The reclamation of the arid lands has been accomplished mainly by individual effort in the construction of small ditches. Wherever it has been possible for a farmer, or several farmers acting in unison, to construct irrigation works by their own labor and without the use of capital, this has been done. The average cost of these ditches and small canals, as given by their owners, has been small, owing to the fact that the farmers have not placed a high valuation upon their own labor, nor have they kept account of the many efforts and failures. All of the time which could be taken from other work has been put upon the ditch, and in most cases many renewals or extensions or relocations have been effected. The building of these has generally been more or less experimental, a line being plowed or dug out, and modified, especially at its upper end, as circumstances required. This

is perfectly feasible with small streams of water, but in the case of large rivers and of undertakings of considerable magnitude there can not safely be anything in the nature of an experiment, for if the first trial does not succeed, it is rarely possible to raise sufficient funds to reconstruct or modify the original design.

Nearly all of the opportunities for the development of small irrigation works have already been utilized or appropriated by individuals, but there remain many opportunities for development upon lines which will require for proper construction the use of large sums of money, such as can be procured only by great corporations, or by the State or National Government. The smaller projects, however, have been usually built without system, and even without any general plan, so that the future development of larger and more comprehensive undertakings is often blocked or rendered impossible by the network of little ditches. It may be possible in some localities to acquire and extinguish these vested rights, but the cost of such proceedings would be a further burden to be added to the expense of overcoming the natural difficulties, and one which must ultimately be borne by the farming population.

It is a fact now generally recognized that any considerable extension of the area irrigated from streams can come only through the successful operation of large enterprises. These, however, have not been favored by popular sentiment nor by legislation, there being a prevalent feeling that the corporations controlling the necessary funds and conducting operations on a large scale may prove a menace. The land laws have been so framed that it is impossible for large associations to obtain legally title to tracts of such size that the sale of these will repay the cost and risk of building a great canal. There are exceptions to this in the cases of the old Spanish grants and of donations to railroad corporations, where it has been possible for investors to acquire considerable areas lying adjacent to one another, and here some of the largest irrigation projects of the country have been successfully undertaken. The conditions of acquiring ownership to the great bulk of the public lands now vacant, however, are such that it is impracticable to attempt to secure title to contiguous areas, and without such title to the land to be reclaimed it is doubtful whether any large canal can be profitably built; for experience has shown that the only safe investment in this line is where the expense of construction is repaid out of the increased value of the land, rather than by the sale of water rights or by annual rentals. The price of these water rights, and the amount which can be charged each year for the privilege of taking water through a large system, are in most States under the control of the legislature or of county officials, so that corporations in this respect are at the mercy of the people rather than the reverse.

It appears, therefore, from a study of the conditions, that no great developments can take place except through State or Government inter-

vention, or through such changes in the land laws as will permit persons undertaking great enterprises to obtain ownership of the lands to be benefited and secure to themselves the increment of value under reasonable restrictions. Under present conditions, should a great project involving the public lands be broached, the lands in question are liable to be filed upon at once by speculators eager to obtain the unearned increment due to the enterprise of others. As a result the farmer who ultimately buys and cultivates the land must not only refund, in one way or another, the original cost of the project, but must do this in addition to paying an increased valuation due to speculation. If the land is worth $1.25 per acre, the Government price, the prospective canal may cause this to increase, say, eight times, or to $10 per acre. The speculator, learning of the project, can, under present laws, rush in and file upon a homestead, and, if fortunate, secure this profit with comparatively little risk or expense to himself. The farmer must ultimately pay this advance, which equitably should have gone to reimburse the outlay for reclamation. In other words, under present circumstances, the farmer is called upon to pay a double cost for reclamation, when under possible theoretical conditions the increase in value of the lands over their sterile condition should have done this.

The rivers of the Western public-land States from which water is obtained for use upon the land may be considered under seven great groups. These are, first and most important, those ultimately tributary to the Mississippi River, including all of the streams east of the Rocky Mountains from the headwaters of the Missouri southward through the basin of the Platte and Arkansas. South of this is the second system, those streams tributary to rivers flowing directly into the Gulf of Mexico, the Rio Grande being the most important, although not the largest. To the west and interlocking with these are the rivers of the Colorado drainage, characterized by the great canyons and gigantic gorges through which many of them flow. Beyond these is the great Interior Basin, comprising groups of rivers which do not flow into others, but which are lost imperceptibly in the sands of the desert areas, or which flow into some salt or brackish lake from which the waters are finally evaporated. In the northwest is the Columbia drainage; and in California the Sacramento and San Joaquin, draining the western slope of the Sierra Nevadas. The last group includes the streams, usually of insignificant length, draining the Coast Ranges and flowing directly into the Pacific Ocean.

Wells.—Although by far the greater part of the acreage of the lands made valuable by the artificial application of water is dependent upon streams, yet wells play a very important part as sources of prosperity. These may be divided into two classes—the artesian or flowing wells, and those from which water must be pumped or lifted by various devices. The flowing wells are local phenomena, and, although attracting popular attention by their novelty, are not worthy of consideration

to the exclusion of the ordinary form of well. In many of the older countries wells have been employed in irrigation since the beginning of historic records, and water has been lifted considerable distances to be applied to growing crops. It is, however, only within a few years that the practicability of utilizing any notable extent of the public domain through this agency has received general recognition. It is true that market gardeners have used windmills and other devices from time immemorial, but that this insignificant method of irrigation would ever be of public importance has been almost entirely overlooked.

Experience in various parts of the country has shown that a farmer who will content himself with a few acres and utilize his resources to the best advantage can make a good home and living upon the arid or semiarid lands by means of agriculture rendered possible by water pumped from a well. The greatest progress in this line has been in subhumid States, including the broad belt from the James River Valley of the Dakotas southward through western Nebraska and western Kansas. There a relatively large population was almost without means of support, owing to the occasional or periodic droughts. After many experiments and failures it was found that continued success was obtained mainly by those who practiced irrigation, this being possible in many localities only by means of well water. Attention being drawn to this fact, systematic endeavors have been made to perfect methods and apparatus, until at the present time large numbers of men are employed in sinking wells and in erecting suitable machinery for bringing the water to the surface and storing it for use as required. There is every reason to believe that continued prosperity will follow the development of small farming in this manner, especially when combined with stock raising, upon the broad grazing lands of the West.

The location of the successful wells, the geologic structure which renders these possible, the quantity of water which can be obtained, and similar facts are the subjects of investigation by this Survey, and the results are being published from time to time. Particular attention is called to the paper in this report by Prof. Robert Hay, relating to portions of western Kansas, eastern Colorado, and adjacent areas in Nebraska. It has been found that, although there are many localities where water can not be obtained in profitable quantities or where it is unfitted for use, yet a thorough search will disclose many places where it is highly probable that a good supply can be had at moderate depth. Endeavor should be made to point out these places as soon as possible and to lay the information before the public as a guide in development. The occurrence is governed by geologic structure, and a thorough knowledge of this, as well as of related facts, is essential before the subject can be said to be well known.

The amount of water which can be obtained from any one well is not usually sufficient to irrigate more than a few acres—from 2 to 10, or possibly more if a storage reservoir is used. This limitation of supply

is in many respects a boon, as the farmer is forced to concentrate his efforts upon smaller areas, and should produce larger results. One of the greatest detriments to the realization of the highest type of cultivation and of civilization upon the public domain has been the attempt by the farmer to cultivate enormous areas and to own everything to which he can possibly lay claim. Where water is obtained from a well, it is necessary to utilize the ground to its fullest extent in that immediate vicinity. As a result, the homes created by this means will tend to cluster in small settlements where the water is available, leaving the broad grazing lands of the semiarid States untouched by the feeble attempts at cultivation.

The cost of obtaining water in this way can not yet be stated, as applying to the country as a whole, for wide information must be collected and brought together, and in many parts of the West the matter is still in an experimental stage. The success attained, however, is such that it is obvious that the cost, though greater than that of the ordinary small irrigation ditch, is by no means prohibitory. This cost is decreasing year by year as in each locality knowledge is obtained of the best methods, and machinery and appliances are devised to meet particular needs. The principal agency employed in pumping water is the wind, but next to this in importance are the various engines employing either steam or gasoline. The gasoline motor is apparently growing in favor, and is being widely used on account of the convenience and ease with which it is operated. Wind power, although often unreliable, is considered the cheapest and is the most widely employed. The water is usually pumped first into small reservoirs constructed on the surface of the ground and from 100 to 200 feet across. Here the temperature of the water generally rises, and it is rendered more fit for application to the plants by exposure to light and air. These reservoirs are often bordered by trees, and serve not only as refreshing and beautifying spots near the home, but become a source of value through the raising of fish.

Artesian wells have attracted considerable attention, but they are probably of less real value than the wells from which water must be pumped. One reason for this lies in their very convenience. Water flowing at all times is cheaply regarded; it is allowed to run to waste, forming swamp places, or is applied too lavishly to the fields. When this water contains, as it often does, any notable per cent of salts, extravagant use injures the soil and results in discouragement to the farmer; so that actually slower progress has been made with these artesian wells than where the conditions are less favorable. The regions within which these occur are being examined with a view to ascertaining the source of this water, its quantity, the extent to which wells can be increased in number, and their probable utilization in various ways. In some places, notably in the Dakotas, the pressure of water from these wells is sufficiently great to be of value in running light machinery; and thus the wells have an interest to others besides the farmer.

The artesian wells of the country as a rule gradually decrease in amount of water delivered and in pressure, although there are many exceptions. This decrease is due not so much to drawing down the hydrostatic head or the reserve store of water, as to mechanical defects in construction or accidental injuries. In many instances the first wells were improperly cased, or even were not cased at all, resulting in leakage from one stratum to another, or in the falling in of the walls. The force of the water, also, is so great that sand is carried to the well, and, accumulating, often clogs it, so that constant care is required in order to preserve the flow of water. Thus it is that after the first few years an artesian well may be a constant source of expense and annoyance, due to many causes, some of which have not been ascertained.

Reservoirs.—There are many parts of the country where it will be impossible to obtain water from perennial streams or from wells, and yet where, as in southern California, the fertile soil and genial climate render possible the cultivation of high-grade, expensive crops. In such instances it is occasionally possible to construct storage reservoirs in which to hold the flood waters of the intermittent streams characteristic of much of the arid region. In other localities, where the development has proceeded to such an extent that all of the ordinary flow of the streams is utilized, attempts are being made to save the excess waters of the spring or of unusual showers, in order that these may be employed to supplement and increase the ordinary supply.

There are also many places, especially within the mountain region and among the foothills, where, with comparatively small expense, dams can be built, closing the outlets to nearly level valleys or small parks, in which great quantities of water could be held each year. From time to time some of these are utilized, but the expense of construction and the difficulties of bringing the stored water from the reservoir and securing control of it have prevented general work along this line.

In the case of the public lands, one of the great obstacles to the utilization of storage reservoirs is the lack of safeguards for water rights. For example, if water is saved in a reservoir high among the mountains by one person or company, for the purpose of employing it upon lands 50 miles or more away, it usually happens that this water must be allowed to flow down natural channels, and possibly by the heads of many small ditches having prior rights to the use of the stream. Theoretically it should be possible to let this pass through the natural channel and recover it below, but in most localities this is practically impossible, owing to the fact that the owners of the various ditches will inevitably capture some of this water during the dry season, or claim it as part of the regular flow of the stream. Unless, therefore, the stored water belongs to the community as a whole, or to ditch owners having priorities to the use of the stream, it appears impracticable to attempt to store water at great distances from the land to be

RESERVOIR SITE AT HUSTON FLAT, IN SOUTHERN CALIFORNIA.

irrigated. This has led to the construction of many low-lying reservoirs, upon the edges of the valleys or out upon the plains, convenient to the land to be irrigated, where they are filled at time of flood or during winter. This method, however, is not economical, as the losses from evaporation are great, and it is often impracticable to fill the reservoirs at proper times.

The Geological Survey has been authorized to reserve suitable sites for reservoirs upon the public lands, and it has found and designated a considerable number of these. But, owing to the imperfect condition of the land laws, and to the general indifference or the fear of interference with private speculation, little public support has been given to the measure. Careful provision for future public needs is not looked upon with favor nor warmly supported when it might interfere with immediate private gain, and in this matter, as in the case of the forests of the country, it is probable that the importance of the subject will not be generally recognized until the available natural wealth has been more nearly converted to private use.

The storage of water, except under the most favorable conditions, is one of the class of undertakings which have not been financially successful. The enormous first cost involved in making a perfectly safe structure, or the destructive and disastrous results following imperfect construction, have deterred possible investors. There is probably no construction involving greater menace to life and property than an insecure dam situated on the main drainage lines and above settlements and habitations. Especially is this the case in the West, where storms of extraordinary violence, or "cloud-bursts," are apt to occur at almost any time of the year. Yet with the progress of settlement it will be necessary to build reservoirs, and due provision must be made for building them under proper supervision and with every regard to permanence and safety. In previous publications of this Survey description has been given of various classes of dams—earth, timber, and masonry—with a full discussion of the cost and character of many already completed and of others designed.[1] It is therefore unnecessary to discuss this matter at length. At present, however, the attitude of investors, especially in the public-land States, where it is difficult to procure ample capital, is toward extreme economy in construction. There is an unwillingness to pay out large sums either for engineering skill or for thoroughness of work, due chiefly to the desire to obtain immediate returns through rapid construction and quick sale of the property. As a result, many of the dams already built are open to severe criticism, and progress in this line has been discouraged.

In any particular case it is generally obvious which of the sources of water supply can be utilized; but there are some cases in which there is room for debate or for critical examination by the expert.

[1] Thirteenth Annual Report of the United States Geological Survey, Part III. Irrigation. American Irrigation Engineering, by Herbert M. Wilson.

Throughout a great part of the country, however, it will be found practicable to cultivate some of the rich soils and to utilize the various resources through the employment of water obtained in one of these three ways. But in nearly every case recourse must be had to exact information, either as to the fluctuations of the stream, the structure of the water bearing rocks, or the probability of securing flood water at regular intervals, and of obtaining suitable materials for the construction of storage dams. A thorough study of all these points is therefore necessary as a prerequisite to the utilization of the remaining public lands. The investigation of matters pertaining to the hydrography of the country, especially as these relate to the geology, is now well under way, and, although far from complete, the information is being utilized with beneficial results.

ARIZONA.

This Territory is fourth among the political divisions containing vacant public land. Its total land area is 112,920 square miles (p. 478), or 72,268,800 acres. Of this land a little over 11,000,000 acres (p. 492) are included in Indian reservations, chief among which, and comprising considerable areas of good agricultural land, are those of the Navajo, Moqui, White Mountain, and Hualpai Indians. Although there are estimated to be 10,000,000 acres of forest, besides 8,700,000 acres (p. 482) of woodland, in this Territory, only one tract has been set aside. This is situated in Coconino County and is known as the Grand Canyon Forest Reserve. It was created by proclamation of February 20, 1893, and is estimated to comprise 1,851,520 acres. It is quadrangular in form, and embraces land on both sides of the Colorado River, being so located as to include points of peculiar interest and grandeur. The estimated area of vacant land disposed of, according to the Report of the General Land Office for 1894 (p. 165), is 4,245,809 acres. Of this amount about 1,751,401 acres have been selected or patented under grants to railroads.

The selections made under the railroad land grants have been mainly along the Little Colorado River and in the forest area south of the Navajo and Moqui reservations. The homestead and desert entries have been to a large extent in the valley of the Salt and Gila rivers, others being widely scattered throughout the eastern and southeastern portions of the Territory. The greatest body of untouched land is south of the Gila River, adjoining the Republic of Mexico, this being almost, if not quite, desert in character. To the north of the Colorado River, on the high, deeply eroded uplands, there are also vast stretches of public lands, as yet unsurveyed and apparently worthless except for grazing purposes. Only about one-fifth of the total area of the Territory has been surveyed and subdivided in the conventional manner into townships, ranges, and sections.

As shown by the map, settlement has been confined almost exclusively to the open valleys of the Gila River and its tributaries and to the higher lands in the vicinity of Prescott. This Territory is among the most arid of all the political divisions of the Union, and the difficulties of obtaining water are most pronounced. In the valleys among the mountains or on the high plateaus a little agriculture is successfully carried on without irrigation, but this is the exception rather than the rule. The greater part of the agricultural development has been in the Salt River Valley at points where water has been diverted from Salt River, and also lower down in the Gila Valley.

The principal available water supply of the Territory is from Gila River, and especially from its largest branch—Salt River. This stream and its tributary, the Verde, have been measured at various points, and computations have been made of the discharge at the Arizona Canal Company's dam, about 30 miles above Phœnix, the figures being given in preceding annual reports of this Survey. A considerable number of canals and ditches have been constructed, taking water from the Salt and Verde, as well as from the Gila itself; and the ordinary summer flow is needed for the lands now under cultivation. There is, however, an enormous amount of water going to waste at various times of the year, following the sudden storms or "cloud-bursts" in the mountains, but these floods occur at such irregular intervals and come with such violence that it is impracticable to attempt to save much of the water. There are a number of localities high among the mountains—notably, one in Tonto Basin—where dams could be built at a cost not excessive as compared with that of similar structures elsewhere.

With the exception of the great Colorado River, which, however, flows in stupendous canyons or gorges thousands of feet below the arable lands, the streams of the Territory are small, and usually intermittent. The Little Colorado and its numerous tributaries up in the plateau and on the Mogollon mesa furnish a supply for small ditches, the principal of these being in the vicinity of Taylor, St. John, and Holbrook, in Apache County. In the extreme southern part of the country, adjacent to the Republic of Mexico, are a number of streams, notably the Santa Cruz and the Sonoita, but the waters of these are claimed for lands now in private ownership, and the supply is far from sufficient for the valleys in which they flow.

There are few notable wells in Arizona, and none which are known to be flowing. Most of the deep wells are put down for the purpose of furnishing water for stock or for railroad purposes, and their supply is thus wholly utilized. Explorations have not been carried on with a sufficient degree of thoroughness to determine whether it may not be possible to obtain larger quantities of water in some of the important valleys. In various portions of the Territory are enormous tracts where the grazing at one time or another is good, but where herds can not be kept owing to the present impossibility of obtaining drinking water. Many attempts have been made to sink wells at various

points, but either on account of the expense involved or for lack of knowledge as to what might be expected, most of these have been abandoned as unsuccessful. On the lower valley lands along the Gila, especially where irrigation has raised the ground water, ordinary wells obtain a sufficient supply for stock purposes, and by means of windmills small areas are watered.

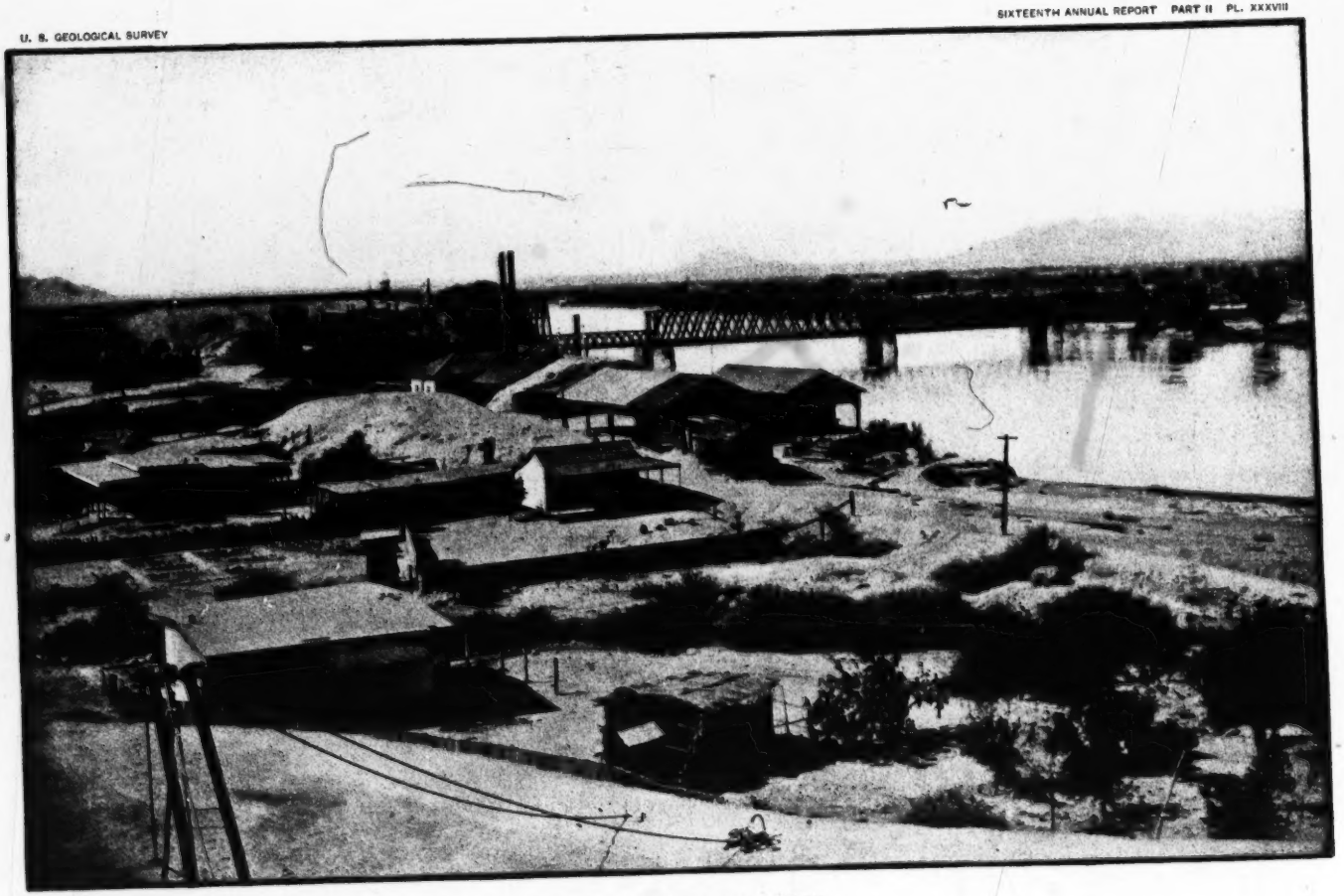
Storage reservoirs have been built in several places in the Territory, principally, however, for the purpose of hydraulic mining. One reservoir—that on the Hassayampa above Walnut Grove—was destroyed, with some loss of life and considerable damage to property, resulting in discouragement to this class of enterprise.

The total water supply of the Territory which can be rendered available for use at reasonable expense is estimated to be sufficient for about 2,000,000 acres of land. This estimate is not made with any claim to accuracy, being based on numerous assumptions and upon scattered measurements. It illustrates, however, the fact that the supply is far less than the demands of the area which has now passed out of the hands of the General Government, and is almost insignificant in comparison with the lands now vacant and needing water. It is, however, fairly well distributed, and it is possible that by developing every known source—springs, streams, wells, and storage reservoirs—homes can be made for many thousands of families and the greater part of the grazing lands can be utilized to far better advantage than at present.

CALIFORNIA.

This great State—the largest among the Western public-land States and Territories—embraces such a wide range of topographic conditions that a discussion of the water supply must be of the most general character. Although the greatest progress has been made here, both in the development of agriculture and in the utilization of the lands, there still remains over 90,000 square miles (p. 478) of vacant public land, or over one-half the area of the State. The greater part of this land is in the southeastern portion of the State, including the great Colorado Desert, Death Valley, and similar barren regions; from here a strip extends northward along the eastern boundary to the lava-covered plateaus in the northern part of the State. There are also vast stretches of vacant land along the northern Coast Ranges west and northwest of Mount Shasta. Much of this latter area, and also the vacant lands along the Sierra Nevada, are forested and have considerable value in timber.

California as a whole is estimated to contain 18,000,000 acres of forest, 27,000,000 acres of woodland, and over 42,000,000 acres (p. 482) of open land, mainly valuable for grazing. Of the part now vacant and open, when surveyed, for entry and settlement (p. 494), there are estimated to be about 6,000,000 acres of valuable forest, 5,000,000 acres of woodland, 27,000,000 acres of grazing lands, and 19,000,000 acres of actual desert, including in the latter some tracts which after a rainy season may furnish a little forage.



COLORADO RIVER AT YUMA, ARIZONA.

The forest reservations in this State are comparatively large, embracing in the aggregate over 5,000,000 acres (p. 492), or less than a third of the land originally covered with heavy trees. The principal area thus set apart is known as the Sierra Forest Reserve, and embraces over 4,000,000 acres, extending along the mountains from the Yosemite National Park southeastward to the vicinity of Bakersfield. The Indian reservations are relatively small, having been cut down from time to time, and are now of such proportions that even when the lands are allotted in severalty and the balance thrown open there will be comparatively small increase in the area of public land.

The railroad-grant lands are an important feature in this State, since they cover large portions of the fertile valleys. It appears that over 6,000,000 acres have already been patented to the railroads or selected by them, and there remain many million acres more reserved or held pending decision as to the rights of the corporations. In the southern part of the State especially the old Mexican land grants are also notable, since these were laid out in such a way as to include the more desirable portions of the country. In some cases they have been a detriment, retarding settlement, and in other cases the ownership of large tracts has enabled private enterprise to construct works upon a scale which would not have been attempted upon public land.

The water supply of the State is relatively large and well distributed. In the northern part, along the ocean, the climate is humid, and although there is a deficiency of summer precipitation, yet it is possible to raise large crops without the artificial application of water. The aridity increases, however, toward the south, and, as previously stated, in the southeastern part of the State, beyond the mountains, deserts abound. A large amount of accurate information regarding the rivers of the State, especially those of the San Joaquin Valley, has been obtained and published by the State engineer, and this material has been supplemented by the field work of this Survey. It is, of course, impracticable to discuss the character of even the more important rivers in a few paragraphs, but the following brief statements will convey a few general impressions:

In the Sacramento Valley, where irrigation is not absolutely necessary but is often of benefit, there is as a rule a large perennial supply of water coming from the mountains on both sides. Along the eastern foothills many ditches have been constructed, originally for hydraulic-mining purposes, but later used for agriculture. In the San Joaquin Valley the water supply from the Sierra Nevada on the east is generally large and well distributed, but on the western side of the valley there are but few streams, and these are mainly intermittent in character. Cereals can be cultivated in this valley without irrigation, even as far south as Kern County, but it has been found more profitable to subdivide the great farms and introduce the cultivation of high-grade crops on small areas.

Beyond the range to the east of the San Joaquin Valley is the narrow valley drained by Owens River, and to the south are the broad interior lands of the Mohave Desert. Here the water supply is scanty, and is obtained mainly from small streams heading in the short, steep slopes of the Sierra Nevada or among the irregular mountain masses lying to the southward, near the coast. Fig. 54 gives a view of Owens River and shows the character of this stream, the most important one in this part of the State.

The numerous ranges skirting or adjacent to the coast furnish a considerable supply of water to the valleys on the western sides, but the streams flowing toward the east and north into the desert are small and intermittent, no living stream reaching beyond the foot-

FIG. 54.—Owens River, east of Big Pine, Inyo County, California.

hills. There are, however, many localities where reservoirs can be built among the mountains, a few of which, as in the cases of Bear Valley and Hemet reservoirs, have already been utilized. Other localities possessing many points of advantage still remain; a view of one of these—that at Huston Flat—is given on Pl. XXXVII.

The greater part of the southeastern end of the State consists of broad deserts, broken occasionally by rocky, sterile hills and mountains, these barren lands stretching from the southern end of the Sierra Nevada to the Colorado River. No living streams are to be found beyond the foothills, and only an insignificant amount of water can be obtained from wells. There is not yet sufficient information at hand to determine whether the probabilities of success will justify

large expenditures in exploring for deep-seated waters over any considerable part of this country. Portions of this area are below sea-level, notably Death Valley on the north and the Salton Sink on the south. It is proposed to bring water to the country adjacent to this latter area by a great canal tapping the Colorado River near Yuma and crossing a part of the desert south of the Mexican boundary. This river, shown on Pl. XXXVIII, is one of the largest streams of the country, and at all times of the year discharges a volume sufficient to irrigate hundreds of thousands of acres.

Artesian wells play an important part in the development of considerable areas in California, especially in the southern part of the State, where, from scarcity of water, they are of especial value and importance. Many of the largest wells, however, are in the San Joaquin Valley, upon lands so situated that they could easily be covered by irrigating canals. Water storage, also, has been tried to a large extent, the reservoirs of this State being more extensive and successful than those of any other part of the country.

The estimates of the water supply of this State show that while there is an excess for the humid and subhumid portions, there is a great deficiency for the remainder of the State, there being probably not enough to cover the lands now in private ownership should these be in such position as to have water brought upon them. It is impossible to utilize for agriculture more than a very small percentage of the vacant public lands, especially those in the southeastern part, although it is probable that by means of wells and storage reservoirs small settlements may be established at such localities that the grazing can be used to better advantage than at present.

COLORADO.

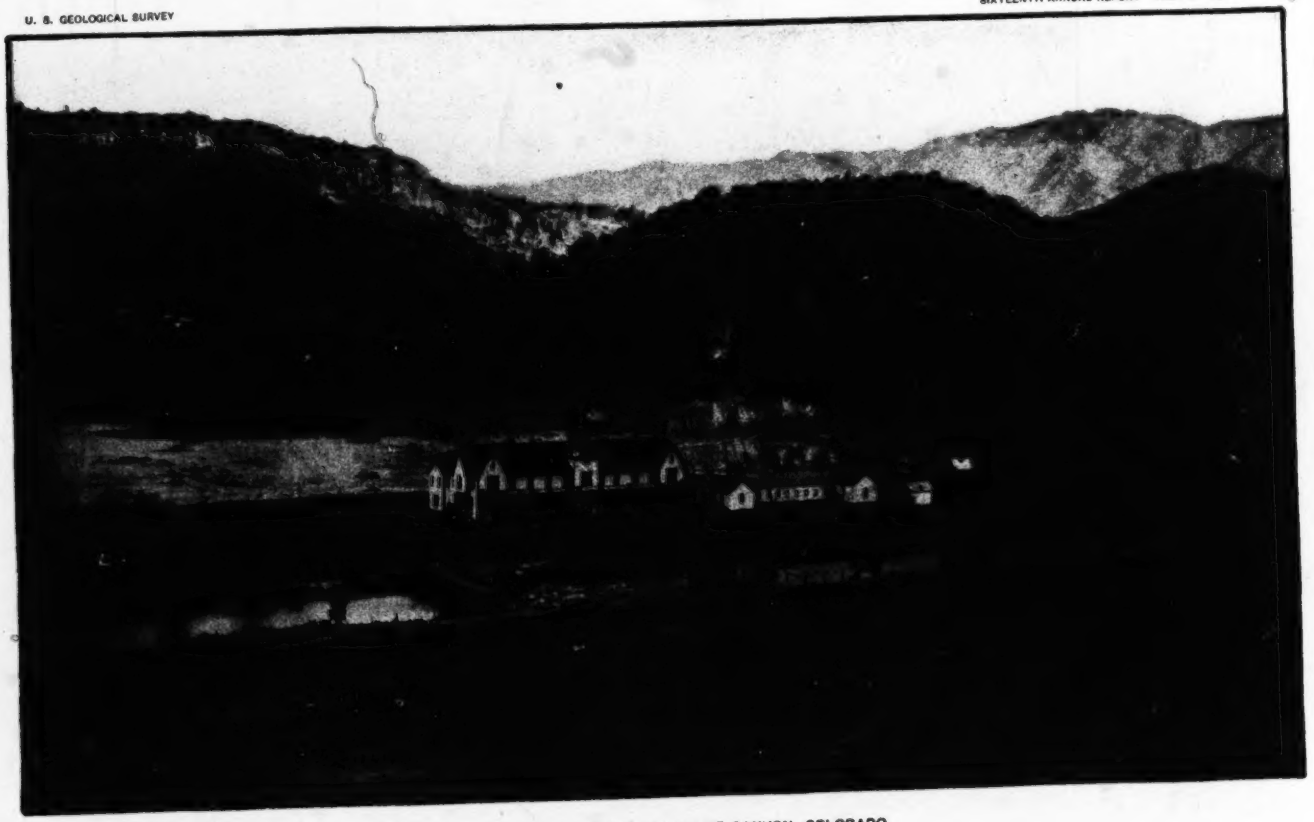
In this State there is an excess of water where it is not wanted and can not be used, and a general deficiency where the soil and climatic conditions are best suited for agriculture. The western, mountainous part of the State is intersected by large rivers flowing with great velocity through narrow, rocky valleys, while the eastern part of the State, extending out upon the great plains, has for its broad, fertile lands an amount of water so small that only the areas fringing the principal drainage lines can be irrigated. The total amount of vacant public land in the State aggregates nearly 43,000,000 acres, almost two-thirds of the entire land surface. It lies mainly along the ranges of the Rocky Mountains and to the westward, a few of the lands of the broader valleys, especially in the vicinity of Grand Junction and Montrose, being taken up. In the eastern part of the State the greater part of the fertile areas out upon the plains have passed out of the hands of the General Government, but owing to crop failures and discouragements due to protracted droughts, many of the claimants to the land have moved away, abandoning their homes and such improvements as

they may have made. Thus, although from the number of homestead entries and from the map it would appear that the country must be dotted with houses, the traveler may ride through township after township without seeing a sign of life, excepting a scattered herd. The land, although not vacant according to the designation here used, is so in fact, and can be purchased from its present owners for trifling sums.

Of the land now vacant, it is estimated that 6,000,000 acres are forested or have growing upon them trees (though often sparsely located) of size sufficient to furnish merchantable timber. Much of this has been burned over, so that it is impossible without a thorough examination to reach any definite conclusion as to its value. Besides this, there are probably 7,000,000 acres of woodland, and the balance of the land, in round numbers 30,000,000 acres (p. 494), is without large vegetation, although furnishing fair grazing during at least parts of the year. Much of this land, especially that beyond the main range of the Rockies, consists of high plateaus deeply cut by gorges, and is accessible only by rocky trails.

The streams of the State of chief value in the development of the lands are the Platte, Arkansas (Pl. XXXIX), Rio Grande, and their tributaries. Along all of these agriculture has progressed rapidly, and has reached a high state of development, rivaling California in success in the cultivation of all but the semitropic fruits. The ordinary flow of the streams is utilized to its fullest capacity, and, especially on the South Platte drainage, large numbers of reservoirs have been built in or near the foothills for the purpose of holding flood waters. This method of increasing the available supply can be utilized to a greater extent, as there are still many localities where water might be held at moderate expense. The examinations carried on by this Survey have shown the existence of good reservoir sites, especially in the basin of the Arkansas, the most notable of these being that at Twin Lakes. By holding the greater part of the flood waters, it will be possible to extend the area under cultivation, but the amount of land which has already passed into private ownership is so great that there is little probability of sufficient supply being obtained for any considerable part of the public lands of the eastern half of the State.

The vast Rocky Mountain region, occupying the central part of Colorado, consists largely of vacant land whose chief value lies in its undeveloped mineral wealth, and next to this, in its forests and capability of producing trees. The altitude is too great, even in the valleys, and the climate too severe, to produce anything but forage plants. To the west, beyond the mountains, are the plateau lands previously mentioned, high and arid, and far above the reach of the water which flows in turbulent streams through the narrow valleys. The chief value of these lands is in the grazing, although there are tracts of considerable extent which should be devoted to forest production. A number of reservations for this purpose have been made in Colorado, the principal



ARKANSAS RIVER, BELOW MOUTH OF CANYON, COLORADO.

one being the White River Plateau Timber Land Reserve, in the northwestern part of the State. This embraces over 1,000,000 acres. Second to this in size is the Battlement Mesa Forest Reserve, embracing over 800,000 acres. There are other similar tracts of less extent, but the entire area thus covered is less than one-third of the probable extent of the mountain forests (pp. 482, 492).

The water supply from wells is an important feature, especially out upon the great plains, where there are no surface streams, but where it is possible to obtain an amount sufficient for the irrigation of small patches of land, besides drinking water for cattle. In the vicinity of Denver, Pueblo, La Junta, Lamar, and in the San Luis Valley are areas where artesian conditions are known to exist, and where flowing wells are used for domestic purposes, and to a small extent in agriculture.

IDAHO.

Idaho is considered one of the best wooded States of the arid region, its narrow northern end being covered to a large extent with forests and woodlands. The broad southern part, however, extends over the lava plains bordering Snake River and is destitute of the larger vegetation, the most conspicuous plant being the so-called sagebrush, which grows on this rich soil often to extraordinary size. The water supply of the State is large, but, unfortunately, only a part can be utilized to advantage, as the most important river—the Snake—soon after leaving the mountains cuts for itself a deep canyon in the lava, and by cascades and rapids falls to a depth of hundreds or thousands of feet below the plains.

The vacant land of the State—over 75,000 square miles—forms nearly nine-tenths of the total area (p. 478). The great mass of it, untouched by settlement, lies in the almost unexplored mountain masses of the central and northeastern parts of the State. On the great lava plains of the Snake, also, are many miles of vacant land, the soil, though fertile, being too dry to attract the pioneer. Along the northwestern edge, adjacent to eastern Washington, the cultivation of cereals by dry farming is successful; and in the valleys of the Weiser, Payette, and Boise many irrigating systems have been constructed, carrying water to farms on the benches and lowlands. There is still a surplus of supply, and the area thus cultivated can be extended, although it is probable that the lands now in private ownership will demand all of the water easily obtainable.

Considerable areas of vacant public land can probably be watered by large canals heading on the Snake River near or below Idaho Falls, and small tracts can doubtless be made valuable by the construction of storage reservoirs upon or near the edge of the lava plains. Several such reservoirs, as, for example, in the vicinity of Mountain Home, have been built and are in successful operation, the relatively low altitude and genial climate rendering possible the production of prunes and similar fruits.

There are a number of deep wells in Idaho, the most notable being in the vicinity of Boise. Some of these furnish hot water, and are of especial value as supplying heat for various purposes. Attempts to penetrate the lava plain have not been successful, although, judging from the occurrence of water in large springs at various localities, it is probable that a supply may be obtained at some points in this manner. The volume of several of the springs emptying into the Snake River is extraordinary, and it is possible that in the future the water power from these springs, or from the river itself, may be utilized to pump water upon the high, fertile lands.

INDIAN TERRITORY.

This area, estimated to include 31,000 square miles, is wholly devoted to the use of the various Indian tribes. It is as a whole humid and well supplied with streams and springs. The greater part is tree covered, it being estimated that over 8,000,000 acres are covered by forests containing more or less timber of value, and 5,000,000 acres wooded. About one-third of the whole area is open or treeless, the greatest extent of grazing land being in the Creek and Cherokee countries, on the rolling lands between the streams tributary to the Arkansas River. Within the wooded areas are stretches of open country, making it difficult to obtain an accurate idea of the relative amount of forest and prairie. If the lands of the Territory are allotted in severalty, there will be left a considerable area of humid or subhumid country to be restored to public entry.

KANSAS.

Although, as previously stated, Kansas contains a very small amount of land belonging to the National Government, yet there are, especially in the western counties, thousands upon thousands of acres to all intents and purposes vacant, title having been acquired by settlers at various times within the last decade. Much of this land probably belongs to loan and trust companies, while considerable tracts have been abandoned and offered for sale in payment of taxes. During the years 1886 and 1887 settlers flocked to western Kansas and eagerly took up land wherever a piece of sufficient size could be had. Town sites were laid out in every direction, and buildings sprang up as by magic. Every point of vantage to secure the permanence of these towns was seized upon, no matter how trivial. Especially was this the case with the towns contesting for county buildings and offices. Nearly every town suitably located put in its bid, and the rivalry became so intense that a petty warfare was inaugurated.

Railroads and local improvements were rapidly constructed or entered upon, and bonds were freely voted for every imaginable kind of enterprise, the counties assuming liabilities for public buildings and for the inducement of railroad construction far in excess of their resources. At the

same time money was loaned freely to the settlers wherever any apparent security could be offered, and agents of Eastern loan companies, rendered reckless or dishonest by the prospect of commissions, bid against one another for opportunities to place loans upon real estate. The stories related of the extravagance of these years, or, rather, short seasons of growth, are almost beyond belief. Men are reputed to have taken up land and secured title simply for the purpose of obtaining loans. Others, with honest intentions of securing homes, were led by the ease of borrowing to expend sums for useless implements and unessential conveniences. Nearly every homestead was mortgaged, often for sums many times its present value, the mortgagees being usually clients of some Eastern trust company, and in innumerable cases persons in moderate circumstances who took this method of investing their earnings for the sake of obtaining a rate of interest in excess of that prevailing in older, settled communities. Although the climate was known to be subhumid and the land subject to droughts, yet persons interested in land sales and in urging onward the excitement did all in their power to diffuse the belief that under the influence of settlement the weather conditions were becoming more favorable and that with the breaking of the prairie sod, the building of railroads, and the planting of trees the rainfall during the growing season would be increased, rendering this part of the State as suitable for agriculture as the eastern end.

The extravagance, misrepresentation, and fallacies which led to the rapid disposal of the lands of western Kansas received a check by the continued droughts which followed year after year and the resulting loss of crops and poverty of the people. A large proportion of the settlers were compelled to leave through actual want; others, becoming discouraged, or perhaps attracted by some new locality, packed up their household effects and got away as best they could, abandoning their farms and homes. These lands now lie idle, the fences are down, and the houses, windowless and doorless, dot the plains in every direction. In some instances, a farmer more fortunate than his neighbors in adapting his methods to the climatic conditions, or perhaps successful in cattle raising, has gathered together a number of these deserted houses, hauling them from all directions, and perhaps adding them to his own as an enlargement, or scattering them about in a motley fashion in his own dooryard, for use as barns and sheds.

It was early recognized that the permanent occupation and development of much of this country rested upon the possibilities of obtaining water. Along the Arkansas Valley a number of canals were constructed, those in the vicinity of Garden City being among the earliest on this stream, having priorities, it is claimed, even over many of the older ditches in Colorado. At the time these canals were built the Arkansas was supposed to be a perennial stream, and little, if any, doubt was entertained as to the ability to obtain water at all times and seasons. But with the development of irrigation in Colorado, and the

rapid increase of the number of canals and of the area of land cultivated, there has been a diminution of water entering Kansas, except during time of flood, and through a great part of the growing season the river is completely dry, or at most contains stagnant pools. Many canals constructed at great expense have been abandoned, or maintained in such shiftless, inefficient manner that the farmers under them are disheartened from further attempts at cultivation by means of the water. It is possible that with proper management, and the diversion of water during flood, much of the land under the canals might be well watered once or twice a year, and produce better crops. With improved methods of irrigation, and with the incentive of the examples of successful farmers, some of these old canals will undoubtedly be utilized in the future.

The valley lands of the Arkansas, however, are not dependent upon the flowing waters, but possess a great advantage in that they can be irrigated from another source. This source is the enormous volume of water stored in underlying pervious soils, easily accessible by wells or deep trenches. The existence of the subsurface waters of the river valleys of western Kansas has long been known, and has often been brought to public attention by popular articles and by official reports. Like every other natural resource, its importance, at one time little recognized, has been seized upon by the so-called "boomers" and exaggerated to the extent of creating distrust and depreciation. It is, however, one of the most important of the natural advantages of the State, and one upon which the foundations of prosperity must be carefully laid.

By a thorough employment of the underground waters, with the best methods, much of the vacant land of the State will be utilized for agriculture, and the remainder can become a source of revenue, indirectly, at least. Taking the Arkansas Valley, as best illustrating these conditions, the general statement may be made that water can be had everywhere within the valley at moderate depths, and in quantities such as to be inexhaustible to ordinary pumping machinery if properly installed. The volume and the rate of delivery are of course dependent largely upon the coarseness of the sands or gravels and upon the thickness and extent of the beds. Careful surveys have not as yet been made to determine the extent and character of these beds, but sufficient work has been done to obtain a broad comprehension of the subject.

In the portions of western and central Kansas where wells can not be obtained at moderate depth it will probably be practicable to store considerable volumes of water by closing the outlets of natural depressions. Favorable localities, although somewhat rare can be found in nearly every county, and by the proper construction of substantial earth dams considerable volumes of water can be held for use upon the lower lands. In one instance, at least, water thus stored has been pumped for use

upon an orchard, and the success attained in this way should induce others to try similar devices. A more detailed discussion of the water supply of the western part of the State is given in the following paper by Prof. Robert Hay, this being the result of a reconnaissance carried on during the fall of 1894.

MONTANA.

Though second to California in size, Montana contains by far the greatest extent of vacant land, there being of this 114,057 square miles, equivalent to 78.49 per cent of the total land surface. As shown by map (Pl. XXXV), the lands in private ownership are irregularly scattered, the greater part being, however, along the eastern slope of the Rocky Mountains, from about the vicinity of Great Falls southward to the Gallatin Valley. Out upon the great plains a very small amount of land has been taken up. The State is crossed by the broad belt of lands granted to the Northern Pacific Railroad Company, but the railroad selections as yet aggregate only a little over 5,000,000 acres. The forest and wooded areas are in the western end of the State, embracing the mountainous region from the foothills of the Rocky Mountains westward to the Bitter Root Range. It is estimated that about 17,000,000 acres can be designated as forest, although a considerable portion of this has been burned over, and that a slightly larger amount has scattered woodland, some of this including the irregular mountains to the east of the main range. As yet no reservations of forest lands have been made within the State, although there has been some discussion as to the practicability of setting aside some of the lands in the vicinity of Flathead Lake.

The water supply of the State within the mountain region of the western portion is large, and the eastern part is traversed by two great streams—the Missouri and its tributary, the Yellowstone. Both of these carry large volumes of water, the summer discharge of each being probably not less than 5,000 cubic feet per second. They are bordered for the greater part of their distance by bluffs, and although there are considerable tracts of lowlands lying in long strips, first on one side and then on the other, yet the great body of rich, undulating plain is at an elevation of several hundred feet above the water level. Each of these rivers has a considerable fall, and it is possible by means of long canals starting well upstream to wind about along the faces of the bluffs and finally bring the waters out upon the broad lands. Reconnaissance has shown that although the engineering features are not insurmountable, the expense of such irrigation will probably be so great and the prospect of immediate returns so small that the attempt should not be seriously considered at the present time.

On account of the difficulty of diverting water from the larger streams, development has taken place among and near the foothills, where the smaller creeks can be utilized by comparatively inexpensive

works. Nearly all of the headwater streams of the Missouri are thus used, and in the Gallatin Valley, especially, the low-water flow of the streams appears to be entirely appropriated. The main Gallatin, Madison, and Jefferson, however, still discharge considerable volumes into the head of the Missouri, as shown by the measurements conducted in the vicinity of Three Forks and on the main river at Townsend. There are many thousands of acres of unutilized land, some of it still belonging to the National Government, in the valleys in the region and to the north of Helena, to some of which it may be possible to take a portion of this surplus water of the tributaries of the Missouri. In the mountains west of Great Falls are still a considerable number of streams whose waters are not fully appropriated, and whose floods can be saved for use upon the broad extent of Government land.

Beyond the mountains, in the western part of the State, the streams are large and have rapid fall. The valleys through which they flow, however, are usually narrow, and there is far more water than is needed for the arable lands. Toward the northwestern corner of the State the climate becomes more humid, and to the north of Flathead Lake the bottom lands are occasionally cultivated without irrigation.

The total available water supply of the State is estimated to be sufficient for about 11,000,000 acres of land, or a little more than has already been disposed of by the General Government. It is probable that in the aggregate no very considerable acreage of the land now vacant can be brought under irrigation without taking the waters which could be used on private lands, unless large projects, such as those involving the use of the waters of the Missouri and of the Yellowstone, are undertaken.

NEBRASKA.

In many respects Nebraska is similar to its sister State, Kansas, but since it extends farther to the westward, and on the north includes considerable areas of sand hills, the amount of vacant public lands is far greater. In the aggregate this amounts to 17,186 square miles (p. 478), or 22.36 per cent of the State—a little less than one-fourth of its whole area. There has not been so much excitement and misrepresentation regarding the western portions of Nebraska as of Kansas, and therefore the disappointments, losses, and suffering have not been so noticeable. Thousands of families, however, have failed in their hopes of making desirable homes, and following seasons of drought many persons have sought assistance from public charity. It is now generally recognized that throughout a great portion of the western end of the State agriculture can be successfully carried on only by means of water artificially applied, and also that even away from the rivers it is possible to obtain sufficient water to cultivate small areas.

The principal body of the vacant lands lies in the region to the north of North Platte River and among the foothills in which the various

tributaries of the Loup take their rise. It also includes tracts of similar sandy nature to the south of the river. In this region the rains soak into the ground without forming streams, leaving the surface so dry that only a very scanty vegetation survives. Occasionally there are years in which the rainfall is so well distributed that the grasses reach a considerable height, furnishing excellent grazing; but again for a succession of seasons droughts burn the vegetation, and the winds blow the sand, changing the shapes of the hills. In these hills are occasionally pools of water, resulting probably from the seepage from adjacent hillocks, the escape of the water downward being evidently prevented by impervious layers. Even in this light soil, in the valleys between the hills, it has been found possible to raise early crops of vegetables, especially if a small amount of water can be obtained. Thus homes have been made there, the farmers raising a sufficient amount to supply their own needs, and depending upon cattle or sheep raising for profitable occupation.

The principal source of water supply of western Nebraska is from the North Platte River, which in this State occupies a broad, sandy bed, the stream in summer being reduced to a depth of only a few inches and spreading out in innumerable channels, aggregating a width of a half mile, or even more. At times of extreme low water the discharge shrinks to less than 1,000 feet, but this amount could probably be augmented by suitable devices for bringing out the water stored under the bed and flood plains. The valley lands along the river are relatively narrow, being in places intercepted by high bluffs. Most of these flood plains have been already covered by irrigating ditches, and on all of them water can be procured at moderate depths by wells. Back from the river the depth to the water increases, but from various attempts made it appears probable that an amount sufficient for domestic use, and even for agriculture on a small scale, can be procured at most points.

In Nebraska, as in Kansas, considerable popular interest has been manifested in the development of a water supply by means of wells pumped by windmills or by engines run by steam or gasoline. Successful experiments have been made in many counties, and it seems more than probable that throughout the greater part of the State prosperity will follow experience and the resulting improvements in methods. In some cases, however, water has not been found at moderate depths, or has been so brackish as to be unfit for use. It is necessary to have a thorough examination made of the geological structure of the country before it is safe to predict the extent to which wells can be utilized.

The available water supply from the streams of the western part of the State has been estimated to be sufficient for 1,500,000 acres, this estimate not including the rivers of the more humid portions, where water is not used for agricultural purposes.

NEVADA.

This State contains the largest proportion of vacant public land, over 95 per cent being still in the hands of the National Government. It is known as the most arid of the States, its water supply when compared with the vast area of the surface being relatively insignificant. There are, however, a considerable number of large streams, and on the side of each notable mountain mass are springs and small creeks sufficient to irrigate farms along the edges of the valley. The most prominent river is the Humboldt, whose drainage is almost entirely included within the northern part of the State. Its waters, however, are not so thoroughly utilized or so important as those of the streams which, rising in California, flow across the State line. The principal of these are the Truckee, Carson, and Walker. In the case of each of these rivers the disadvantage of drawing State lines irrespective of natural divisions is apparent. The upper catchment areas, containing reservoir sites where floods might be held for use in dry seasons, are situated in the State of California, and in counties whose inhabitants have no interest in the development of the lower lands. The most fertile areas, and those upon which the water could be used to best advantage, are in Nevada, but under present conditions it is impossible for the owners of these lands to utilize many of the best storage sites, not only on account of the expense, but also on account of the difficulties of securing favorable legislation from another State.

The small portion of Nevada which has been disposed of by the General Government is mainly in the extreme western part, in the valleys near the California line. Scattered patches of land disposed of in one way or another are also to be found along the Humboldt River and in some of the interior valleys, but in the vast expanse from the Utah line southwestward across the State to the California line there is scarcely a spot taken up. On the map the scattered dots exaggerate the actual extent of land in private ownership, since it is impossible to represent these in their true proportion on this scale. Of this land comparatively little has been obtained directly from the National Government by the settlers, the greater part being portions of the 2,000,000-acre grant made by Congress to Nevada for school purposes in place of sections 16 and 36, usually reserved for this purpose in each township.

NEW MEXICO.

The Territory is characterized by the enormous Spanish grants made previous to the acquisition of the country by the United States and subsequently confirmed by patents from the General Land Office. Some of the best portions of the country have thus passed into private ownership. There still remain vacant, however, 85,302 square miles, or 54,593,280 acres, this amount being very nearly seven-tenths of the entire Territory. The greater part of the vacant land is in the south-

ern and southeastern portion, adjacent to Texas, and also in the northwestern portion, near the Navajo Indian Reservation. Through the center of the country the Rio Grande flows, furnishing an ample supply of water for the lowlands. This is the principal river, and is notable not only from this fact but from the interstate and international questions which are becoming more and more pressing each year. The stream rises in southern Colorada and flows across the San Luis Valley, in which some of the larger canals of the United States derive their supply from various points along its course. Crossing the Colorado State line, the river enters narrow canyons and passes in succession through gorges and valleys until it reaches the narrow pass above El Paso. Here it becomes the boundary between the Republics of the United States and Mexico, and as such has international importance.

The loss of water by evaporation in passing through the broader valleys, combined with the large diversions of waters from its sources in Colorado through New Mexico, tends to diminish the flow of this stream, so that long before it has reached the southern boundary of New Mexico its bed is often dry in summer. As a result the canals on either side of the river, rendering habitable the country about El Paso and the Mexican towns, do not obtain a sufficient supply; and with the continued diversions above, the prospect for the future of these towns is not bright unless water can be obtained in some other way or held by storage dams. Measurements are now being made of the volume of the river at various points, in order to give data for the better discussion of the problems involved.

In the southeastern part of the Territory is the Pecos River, flowing southward into Texas and finally uniting with the Rio Grande. This stream, especially in the lower part of its course, has a large perennial supply, due in part to the springs which occur in the vicinity of Roswell and farther south. The irrigating system[1] along this river is one of the most notable in the United States, on account both of its magnitude and of the thoroughness with which it has been planned and executed. One great advantage has been possessed by the company owning this great system, in that at the time work was begun there were few if any small irrigating ditches whose water rights interfered with the laying out of canals and reservoirs. These, therefore, could be designed to utilize the natural resources to their fullest extent. One of the most notable features is the enormous size of the storage reservoirs, constructed at relatively small expense. The topography has been unusually favorable, and has made possible the ponding back of the Pecos River for many miles by dams of heights not greatly exceeding 50 feet. The dam of one of these storage reservoirs, that at the head of the main canal, has been described and figured by Mr. Wilson.[1] During

[1] Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation; American Irrigation Engineering, by Herbert M. Wilson, C. E., pages 187-191.

1895 a still larger reservoir, known as Lake McMillan, has been built about 10 miles above the dam mentioned, having an estimated capacity of 138,000 acre-feet. The dam holding back this immense amount of water is 1,686 feet long and only 56 feet high at the lowest point in the stream channel. The water supply for these storage reservoirs is obtained from the flood discharge of the stream and partly from the spring rivers above mentioned. The remarkable springs from which these streams flow are comparable to those of Texas, and may be considered one of the greatest sources of permanent wealth for New Mexico. In the vicinity of these springs are a number of comparatively shallow artesian wells, few if any being at a depth of over 300 feet. Some of this water is used for irrigation in a small way.

With the exception of the Rio Grande and Pecos, the streams of the Territory are small, and many of them are intermittent in character, flowing only in times of flood. The principal exception is the San Juan River, in the extreme northwestern corner of the Territory. This river receives a large perennial supply from the mountains of Colorado.

The aggregate water supply of New Mexico available under ordinary circumstances has been estimated to be sufficient for about 4,000,000 acres, or about one-fifth of the land now in private possession. It is probable that by the development of wells and by storage systems considerable areas of the public land may be reclaimed. The greater part, however, will probably have its best use for grazing purposes and for the production of firewood and timber.

NORTH DAKOTA.

In this State over four-tenths of the land area has been disposed of and about one-tenth reserved, mainly for the use of the Indians. The remainder, aggregating in all 33,090 square miles, or 47.14 per cent (p. 498), still belongs to the General Government and is open to settlement. This vacant land is found in small patches in the central portion of the State, and increases in extent toward the west, the third of the State adjoining Montana being almost entirely unoccupied. In this part of the State, especially beyond the Missouri River, the surface is undulating or deeply ravined and so greatly cut by drainage channels that agriculture, except in a few valleys along the principal creeks, can not be conducted on a large scale. In the eastern end of the State, in the James and especially in the Red River Valley, are the great wheat farms which have rendered this country famous. The greater part of the public land is mainly valuable for grazing, although there are local occurrences of beds of impure coal, or lignite. Very little of the land is wooded, except, possibly, along the streams.

There are few sources of water supply available for the irrigation of the arid public lands of this State. The Missouri flows through the State and carries a large volume of water, but it is bordered by bluffs, and the fall of the river is so slight that it has been found impracticable

to attempt to divert any of the water by means of canals. Its tributaries, flowing in from the west, are mainly intermittent, and they, too, are at a level so much below that of the arable lands that, except in a few instances, it will be impossible to use them for irrigation. The principal dependence must be placed upon wells, and fortunately these can be had over large areas. The deep wells in the James River Valley are artesian in character, delivering large quantities of water. In the Red River Valley, and also at localities to the east of and adjacent to the James River Valley, are shallower artesian wells, obtaining their waters from the glacial gravels. The water of nearly all of these flowing wells is impregnated to a greater or less extent with mineral salts, rendering them somewhat unpalatable and necessitating considerable care and skill in applying the water successfully to the crops. By proper cultivation and judicious use of the water, it has been proved that irrigation can be conducted through a series of years without overloading the soil with injurious mineral matter. The extent of the artesian basins has not yet been clearly defined, nor have the conditions of the western part of the State been studied with a sufficient degree of care to give a thorough knowledge of the probabilities of obtaining water supply at various points by wells, but from what is known it is probable that small farms can be located in nearly all of the western counties, the surrounding lands being used for cattle ranges.

OKLAHOMA.

The lands comprising this Territory were held for the benefit of the Indian tribes until settlement had progressed westward beyond them and the adjacent areas in Kansas had been almost completely taken up. These lands, lying partly within the humid region, were long looked upon with covetous eyes by the white man, and many illegal attempts at settlement were made. Arrangements were finally entered into with various Indian tribes for purchasing these lands, and after survey they have been thrown open to the public. During the time necessary to complete the purchase and subdivision, popular attention was drawn to these lands, and when they were finally thrown open to entry there was a great struggle to secure possession of the more desirable spots. The last of these great scrambles for public lands was that following the opening of the Cherokee Outlet by proclamation of the President on September 16, 1893. This outlet contained nearly 6,500,000 acres, and was divided into seven counties. The great influx of population on that and succeeding days can best be judged by the fact that within the week following September 11 about 115,000 certificates were issued, entitling the holders to enter upon the lands after the date named for the purpose of taking up homesteads or town lots. Within a few days over thirty towns were established, some of which reached a population of more than 5,000. Over 20,000 homestead entries were made within the next six months. Of the entire area of the Outlet, there was suffi-

cient to make fewer than 40,000 homestead claims of 160 acres each. When it is remembered that the greater part of the western half of the area is unsuitable for homesteads on account of aridity, it is apparent that there were from five to six times as many certificates issued as there were suitable homesteads. As a result the struggles over the most desirable localities were severe and prolonged. Almost innumerable contests have arisen, both privately and in the courts. Owing to the still unsettled condition of affairs in the Cherokee Outlet and in other parts of Oklahoma, it is impossible to make satisfactory estimates as to the amount of public land still vacant. It is probable, however, that for the Territory as a whole there is less than 40 per cent now open to entry, this being principally on the western side and in the long strip north of the Panhandle of Texas, now known as Beaver County. The lands here are similar to those of southern Kansas, are in general fertile, slightly undulating, and occasionally produce good crops. The dependence for water supply must be placed mainly upon wells, as the streams of this part of the country are small, and unless reinforced by storage reservoirs are of little use.

OREGON.

In this State the great bulk of the land to the east of the Cascade Range still belongs to the National Government, together with a considerable area of forest along the coast and among the high mountains. The aggregate area of vacant public lands is estimated to be 55,887 square miles (p. 478), or 35,767,680 acres, this being a trifle less than three-fifths of the area of the State. The principal tracts disposed of to individuals lie in the valley of the Willamette and in the smaller valleys to the south and west. In the extreme eastern portion are also numerous entries, in the valleys among the Blue Mountains, where water can be obtained. Next to Washington this State is one of the best timbered in the West, the estimated area in forest being over 20,000,000 acres, and in woodland 17,000,000 acres (p. 482). Part of this has, however, been burned or cut over, and the present knowledge of the condition of the timber is somewhat meager, so that these figures may be above the actual facts. The largest forest reserve in the United States, that of the Cascade Range, lies within this State. It includes nearly 4,500,000 acres, and extends from the Columbia River on the north, south along the mountains nearly to the California line. Besides this there are smaller reservations of relatively insignificant size.

The greater part of the vacant public land is within the great interior basin, the streams of which do not have sufficient volume to cut their way to the ocean. They flow for a short distance from their sources among the mountains, and gradually dry up, or flow into some lake or marsh from which the water is evaporated. The supply is very small in comparison with the land to be supplied, and it will be necessary to use storage reservoirs and well water, wherever it can be obtained, in order to utilize the land.

SOUTH DAKOTA.

In South Dakota the area vacant aggregates 25,204 square miles, or nearly one-third of the area of the State. In addition to this should be considered the large area reserved—15,951 square miles—the greater part being for the use of the Indians. These Indian reservations will probably be cut down from time to time, thus adding to the area in the hands of the Government. Nearly the whole of this vacant land is west of the Missouri, between it and the Black Hills. Much of it is "bad land," and has no apparent value, except possibly for grazing. Along the streams, however, are many places where farms can be made, and settlement is progressing steadily into this area. In and about the Black Hills nearly all of the well-watered lands have been taken up, but considerable tracts of forest are still in the hands of the Government. These forests, however, are being cut or burned over, so that the remaining timber will probably have little commercial value in the future.

In the eastern part of the State, where the lands are now almost completely in the hands of private owners, the rainfall is usually well distributed throughout the summer and crops are fairly successful; but droughts are of frequent occurrence, and in many of the counties there has been considerable suffering owing to the fact that all dependence has been placed upon some one crop, the conditions for which were unfavorable. Irrigation has been introduced in a small way, and the people are being educated to see the benefits of cultivating small areas by means of an artificial supply of water. The James River, however, the principal stream east of the Missouri, carries but a small amount of water and has such slight fall that it has not been found practicable to build irrigating ditches from it. In a few places water is lifted from the river by pumps, some of these being driven by the stream itself.

The most important sources of the water supply of the James River Valley are the artesian wells, which bring up water in considerable quantities from various depths. This water rises above the surface, and at some places has sufficient pressure to drive machinery, besides furnishing municipal supply. By connecting suitable fire hose to the pipes, a stream of water can be thrown over the highest buildings of many of the more important towns. The value of this artesian supply is very great, not only for municipal and domestic purposes, but also for agriculture. Unfortunately, however, much of the water is impregnated with mineral matter, rendering it essential to use considerable care in applying it to growing plants.

West of the Missouri River the water supply is relatively small and precarious. Attempts to secure artesian water have not as yet been made within the great body of the public lands near the Black Hills, streams and springs combined furnishing ample water for the lands in that vicinity. It is probable that in many places wells can be success-

fully drilled, and in others storage reservoirs can be constructed to hold flood waters, rendering successful agriculture possible within the greater part of the lands now unutilized.

TEXAS.

As previously stated, this State, on coming into the Union, retained possession of the lands within its borders and instituted its own methods as to the disposal of the unclaimed areas. The greater portion of these have now been disposed of, but the State still retains title to many millions of acres, situated mainly in the extreme northern and western extremities. In northern or Panhandle Texas the lands are high, being upon the Llano Estacado, where water is obtained with difficulty. Deep wells, however, have been successful in obtaining sufficient for stock purposes. In the western end of the State, beyond the Pecos, the country is more sterile, is often desert-like in character, and over large tracts does not at any time of the year support vegetation sufficient even for grazing.

The greater part of Texas is well watered, the most notable feature of the supply being the occurrence of large perennial springs in an irregular line across the central part of the State, notably at Austin, San Marcos, San Antonio, and Del Rio. There are also a number of horizons at which artesian water is found, and deep wells, especially valuable for city supply, have been put down at various points from Waco to Galveston. A more complete discussion of the waters of the State will be given in forthcoming reports by Prof. Robert T. Hill, and in other publications now in preparation.

UTAH.

Utah includes an area of 84,970 square miles of the region lying almost in the center of the western or arid half of the United States. By reason of its medial position and widely varied topography, as well as of its progress in agriculture by irrigation, it typifies more nearly than any other one political division the conditions prevailing in the arid regions. A description of its water resources and the method of their employment—the deficiencies of supply, and the improbability or impossibility of ever utilizing large tracts of desert land—epitomizes the narrative of conditions throughout the West. Of the area above mentioned 2,780 square miles, or 3.27 per cent, is water surface. Deducting this amount, the land area is 82,190 square miles, or 52,601,600 acres.

A large proportion of the surface consists of high mountains, whose altitudes range from 10,000 to 12,000 feet. The greater part of the Territory is at an elevation of from 4,000 to 6,000 feet above sea-level, 46,000 square miles, or 54 per cent, of the land surface being at this height. A small amount, 1,500 square miles, is lower, being mainly in the extreme southwestern part of the Territory, along the Colorado River and its tributaries. The remainder of the area, 37,470 square

miles, or 44 per cent of the total, is above 6,000 feet and consists of elevated plateaus or mountain areas containing relatively few valleys suitable for occupation.

Two great catchment basins or systems of drainage receive the flowing waters of Utah. These are the Colorado River system and the great interior basin, of which the area tributary to Great Salt Lake, Sevier Lake, and other sinks forms a part. In area within the Territory these are of almost equal extent, the Colorado basin comprising 41,422 square miles, and the interior basin, with its numerous lost streams, including 43,548 square miles.

The vacant public lands in Utah aggregate 43,077,120 acres, or 67,308 square miles, being 81.89 per cent of the land surface of the entire Territory. Of the remaining area 7,812 square miles have been disposed of in various ways to individuals or to railroad and other corporations, and about an equal area, 7,070 square miles, or 8.60 per cent of the entire land surface, is held for Indian and other reservations. These reservations contain much good agricultural land to which water can be taken, and it is probable that many of these will from time to time be thrown open to entry and settlement under the homestead laws. Adding the area of these reservations, therefore, to the vacant public lands, it appears that over nine-tenths of the area of this Territory is still at the disposal of Congress.

That portion of Utah (7,812 square miles, or 9.51 per cent) which has passed out of the ownership of the General Government is widely scattered, but the main body is in the northern-central part of the Territory, and extends in a comparatively narrow strip west of the Wasatch Mountains, embracing the valley lands to the east of Great Salt Lake, and thence running southward along the east side of Utah Lake and through the valleys of central Utah. The lands in private ownership, when depicted upon the map of the Territory, outline the valleys through which flow perennial streams. Besides the larger groups of settlements above described, which are mainly within the great interior drainage basin, there are scattered areas of settlement trending southwesterly across the Territory down to its lower corner on the Virgin River. These are principally on the headwater valleys of streams tributary to Colorado River, far above the great canyons which traverse the southeastern and southern portions of the Territory.

The Land Office surveys and subdivisions are in a general way confined to this central portion of the Territory. In the aggregate, about 24,000 square miles have been thus subdivided, this being a little less than 30 per cent of the entire land surface. Comparing the area surveyed with that which has been disposed of, it is apparent that this work has progressed over an extent of territory about three and one-half times that which has been finally disposed of. The rate of disposal of the land is comparatively uniform, averaging for the last five years nearly 208,000 acres, or 325 square miles, per year, or 0.39 per

cent of the entire area of the Territory, and 0.48 per cent of the total vacant land. If this rate were kept up continuously, it appears that it would require over two hundred years to exhaust all of the lands open to settlement. From the necessity of the case, however, this rate is constantly decreasing, as the better lands, or those more favorable for immediate development, are first taken, restricting the choice year by year. The rate of disposal will be lessened also by the fact that the railroad lands included in the above will before many years be completely selected, and will not appear in this total.

Of the land disposed of, which in round numbers amounts to 5,000,000 acres, 747,124 acres, or about one-seventh, consists of land selected by the Union Pacific and Central Pacific railroads, under the act of July 1, 1862, and subsequent enactments. The remainder, 4,262,876 acres, has been taken up mainly under the operations of the homestead, desert, and preemption laws, a relatively small amount being acquired by sale of coal and other minerals, or entered by means of warrants and land scrip. In other words, it appears from these figures that 8.10 per cent of the area of Utah is now held by individuals, or perhaps to a small extent by companies, through titles obtained by purchase or settlement under general land laws, and that an amount not exceeding 1.42 per cent is held by purchase from railroad companies. All of these are selected areas, and presumably contain the best farming lands of the Territory, or at least those considered best under present conditions, and which could most easily be brought under cultivation by irrigation. There are unquestionably other areas possessing soil as fertile, but these have not been taken up because of the difficulty or impossibility of obtaining water.

Besides the 747,124 acres of land selected by the railroad companies, these corporations virtually own an enormous tract of land which has been included in the estimate of vacant or reserved public lands, not having been selected and patented by the companies. This tract extends in a belt across northern Utah, and consists of the odd-numbered sections for 20 miles on each side of the constructed line. Assuming that the length of the railroad line across Utah is 200 miles, this would entitle the railroads to about 2,560,000 acres, or nearly 5 per cent of the land area of the Territory. Under present regulations these lands are usually not selected and patented until sold by the railroad companies, and thus taxation is avoided.

For comparison with the figures given above may be quoted the result of the enumeration of the farms of Utah prepared by the Eleventh Census. These results, obtained by visiting every farm in the Territory, show that, in round numbers, there were, in 1890, 1,323,705 acres included within farms, according to the general acceptance of that term. That is to say, the farm area of 1890 formed 26.47 per cent of the lands now disposed of by the General Government, and 2.52 per cent of the total land area of Utah; or the farm area could be extended four times before including all of the selected lands of the Territory.

But not all of the area included in farms is improved or under cultivation The census report on irrigation (p. 218) shows that 263,473 acres were irrigated, or about one-half of 1 per cent of the entire area of the Territory, or nearly 20 per cent of the farm area. Assuming that water could be taken to all of the lands above mentioned, the irrigated area must be increased five times to equal the extent of the farm area, or about sixteen times to equal the area of the land now mainly in the hands of individuals who have purchased or homesteaded it, presumably for agricultural purposes.

Not only is the amount of land now in the hands of individuals enormously greater than the area irrigated or improved, but each year large additions are being made, as shown by the rate of disposal noted above. Annually titles are being acquired to an additional area of land nearly as large as the total area irrigated in the census year.

The matter of most direct public interest in regard to the vacant public lands of Utah is that of their reclaimability and value in building up the future State. As shown by the above figures, these lands form nearly 90 per cent of the total area, but they are of such character that settlers have passed them by in choosing localities for their homes. A great part of them consists of mountain ranges or elevated plateaus, gashed by gorges and canyons in such a way that they are almost inaccessible, and as a rule they are in a climate so arid that nothing can be raised without the application of water. Disregarding areas the soil of which is too rocky for cultivation, there still remain enormous areas, of unknown extent, the reclaimability of which depends wholly upon the question of water supply. It has already been shown that the area under irrigation in the census year was but about one-half of 1 per cent of the total area of the Territory. Further than this, it may be said that statements from thousands of irrigators in the Territory demonstrate that the available water supply was largely taken up, and that even this area was not so fully watered that year, on account of scarcity of water, as it should have been in order to produce the best results. In other words, the accessible water supply has been used for this comparatively insignificant area. But there remain the flood waters, and those of the nonirrigating season, and the waters of large rivers which, from engineering difficulties, have not been employed.

The use of stored waters for the reclamation of arid lands is still somewhat a matter of conjecture as to financial results. The only known successful projects on a large scale are those of parts of California where the value of the products is exceptionally large, so that it is impossible to predict with any degree of certainty the proportion of flood waters which can be utilized profitably. The future reclamation of these vacant public lands depends not so much upon the quantity of water as upon the feasibility of any given project from a financial standpoint, for it is hardly to be assumed that even the Government, State

or national, will invest money in works which will not pay their operating expenses and a very small amount toward a sinking fund.

The investigations of water supply, which have been carried on for a number of years, have been confined to a relatively few streams, but the general conclusion reached is that the quantity available is far less than has been previously estimated, and even with storage it will not be possible to increase the area under irrigation many times. The large river of the Territory—the Colorado, with its branches, the Green and the Grand—is practically of little use in the reclamation of the great body of vacant land on both sides. It is impossible by any known means to bring even a small percentage of the waters of this great river upon the arid lands.

The total water supply of the Territory has been estimated to be sufficient, with careful utilization and a thorough system of storage, to cultivate annually 4,000,000 acres. Of course, estimates of this character must be very general, since they depend upon a number of factors the value of which can not be accurately known until water measurements have advanced to a greater degree of completeness. Comparatively few of the rivers have been measured, and little is known as to the actual amount of water required and the proportion supplied by seepage under various conditions. Enough is known, however, to state with some degree of confidence that there is not enough water to irrigate all of the lands in private ownership, if these are so located that water can be brought upon them; but in this connection it must be stated that not all of this private land can be brought under ditch; and, on the other hand, there are thousands of acres of Government land to which water can be taken without interfering, probably, with established water rights.

Measurements of the water supply have been carried on as described in former annual reports, a few typical rivers being chosen. One of the most important series of investigations has been that by Prof. Samuel Fortier[1] upon the Ogden and Weber rivers. These water measurements have been directed especially toward ascertaining, not only the supply available at certain points, but also the increase due to seepage, or the invisible inflow from widely distributed springs. During the summer of 1894 series of observations were made upon the Ogden and Weber rivers, the points of measurement being so chosen that the total inflow for a given district could be compared with the total amount leaving the district.

The topography of the Ogden River drainage basin presents particularly favorable conditions for determining seepage. This river, which drains a portion of the northern part of the Wasatch Mountain area, flows east through a deep canyon in that range and joins Weber River a few miles above its point of discharge into Great Salt Lake. All the

[1] The Utah Agricultural College Experiment Station, Bulletin No. 38, Preliminary Report on Seepage Water and the Underflow of Rivers, by Samuel Fortier, hydraulic engineer, February, 1895.

water flowing from this upper catchment basin must pass through the rocky canyon. Water is used for irrigation in the broad valley above the canyon, and at the lower end of this canyon the river is almost completely diverted into numerous large canals. A station was established in the canyon, where observations, continued day by day, enabled computations to be made of the mean daily discharge of the river. The amount of water flowing into the upper valley by numerous creeks was measured twice during the summer season, and careful estimates were prepared, showing not only the quantity of water in these streams but also the amount which was taken out by the numerous ditches and canals. Comparing these quantities, it was found that from July to September the outflow from the valley was in general more than the amount entering by surface streams, and this was especially remarkable in view of the fact that nearly the whole of the inflow was taken by one or another of the canals and ditches, leaving

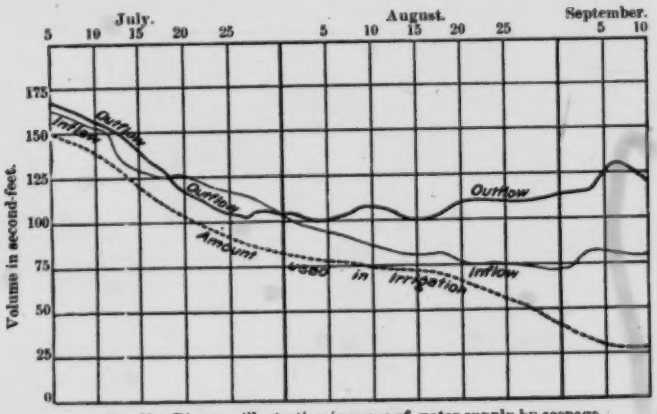


FIG. 55.—Diagram illustrating increase of water supply by seepage.

the channels of the various streams almost dry. In many instances, although the bed of a particular creek was without flowing water for some distance below the head of the particular canal, yet within a few miles water was seen, and this gradually increased in volume until there was a quantity sufficient to supply a lower ditch. At the outlet of the valley there was found flowing at all times during July an amount nearly equaling the aggregate of the inflow. In August and September this amount gradually increased until the outflow in the early part of September was nearly double the inflow.

These facts are best illustrated by the above diagram (fig. 55), in which the light line represents the quantity of water flowing into the valley and the dotted line the quantity used for irrigation. If no water returned by seepage or by percolation from the mountains, the outflow

from the valley would be represented by the vertical distance between these two lines; but the actual amount is shown by the heavy line, which by its position above the base of the drawing shows the total amount escaping into the canyon.

This information relating to Ogden Valley is valuable not so much from its local application as because this condition is typical of water supply not only in Utah but in all parts of the arid region. If no water were used for irrigation during any part of the season, it is fair to assume that during August and September the outflow of the main stream from the valley would be nearly related to the inflow through its numerous tributaries. From measurements made in other parts of the country it might be safe to assume that the outflow during these months would be far less than the inflow, and that under any natural condition the outflow would not be greater. Here, however, it is shown that the outflow far exceeds the inflow; and thus it appears that the putting of water upon the land by the many irrigating ditches tends to increase the midsummer discharge of the main stream.

This increase of water by seepage has its limitations, as pointed out in the early part of this paper (p. 471), and too great dependence must not be placed upon the value or continuity of the seepage, as more thorough methods of cultivation will undoubtedly tend to reduce the quantity thus obtainable. There are many valleys of Utah situated similarly to that of the Ogden River, and it is purposed to continue these measurements in order to ascertain local peculiarities and to obtain more definite information concerning the extent and fluctuations of the seepage waters.

Utah possesses one advantage over many other portions of the arid region, in that its principal streams are short, rise within the limits of the Territory, and can be controlled by local customs. The principal exception to this is the Bear River, which, rising in Utah, flows into a corner of Wyoming, then back into Utah, swinging across the line again into Wyoming, then into Idaho, and, crossing the southeastern corner of that State, turns back again into Utah. The elevation of the greater part of this course is, however, so great that the need of water is relatively small, but in future utilization of the river the question of water storage in Idaho for the benefit of lands in Utah will be one of considerable importance. The facilities for such storage are unusual, as has been pointed out in preceding papers.[1]

WASHINGTON.

This State, lying in the northwestern corner of the country, is probably the most humid of those west of the Mississippi Valley. Along the seacoast the precipitation is excessively heavy, and the mountains are clothed with dense forests extending inland north of the Columbia.

[1] Eleventh Ann. Rept. U. S. Geol. Survey, Pt. II, Irrigation, pp. 66-70; Twelfth Ann. Rept., Pt. II, pp. 325-334; Fourteenth Ann. Rept., Pt. II, pp. 118-121.

The vacant public land aggregates nearly one-half the area of the State (p. 478), and in addition to this over one-tenth of the land surface has been reserved for the Indians and for forestry purposes. The State is crossed by the broad land grants of the Northern Pacific Railroad Company, these covering much of the best farming land. The main body of vacant land is within the Cascade Range and directly west of the vast forest region to the north of the Columbia, and lies also out upon the broad, dry plains of the central part of the State. In the eastern end the humidity is such that wheat is raised by dry farming, the productiveness of this area being well known.

Within the tree-covered regions the water supply is large and well distributed, being often in excess of the needs of the relatively small

FIG. 56.—Clear Creek, Wyoming.

areas of the arable land. Out upon the plains of the Columbia, however, the question of obtaining sufficient water is still unsettled. Attempts at drilling deep wells have been prevented by the great thickness of the lava underlying these plains and the expense necessarily involved. The Columbia itself, although one of the largest rivers of the country, and having an estimated low-water flow of 60,000 cubic feet per second, can not be employed in irrigation, as it is bounded by bluffs and cliffs hundreds or even a thousand feet in height. The valleys west of the Columbia and immediately east of the Cascade Range, although having a very slight rainfall, are well watered by the numerous streams rising among the lofty, snow-covered summits. The principal stream of this area is the Yakima, whose waters are employed

to a small extent in irrigation. The storage facilities are exceptionally fine in the glacial lakes at the headwaters of these streams, and great quantities of water can be held at small expense for use upon the fertile lands stretching out to the Columbia. One of the most favorable opportunities for development is in this part of the State.

WYOMING.

This State as a whole is notable for its large perennial water supply, several of the important rivers of the arid region having their origin within its boundaries. In the southeastern part of the State is the North Platte River and its principal tributary, the Laramie. On the north are numerous streams flowing out of the Big Horn Mountains, among the most important of which is Clear Creek (fig. 56). To the west of these mountains is the Big Horn River itself, and in the southwestern part of the State are the headwaters of Green River. The development and utilization of these sources of water supply have proceeded slowly, and the State as a whole, owing to its high altitude, has been considered as chiefly adapted to grazing. There are, however, many valleys where the climate is similar to that of eastern Colorado and is highly favorable to the success of ordinary crops.

The vacant lands aggregate 83,644 square miles, or 85.72 per cent of the area of the State. In addition to this should be considered the Indian and forest reservations, embracing about 8 per cent. In this area of reservation has been included the Yellowstone National Park and the additional forest reserve to the east and south. A deduction from the area vacant should, however, be made to cover the lands not yet selected under the land grant of the Union Pacific Railroad. This crosses the southern side of the State and includes considerable areas of land having very small value on account of its altitude and rough, desertlike character. Probably the best farming lands in the State are those in the southeastern part, along the Platte, and on the northern border, in the valleys east of the Big Horn Range. There are, however, vast tracts of land still in the hands of the General Government, especially in the Big Horn Basin (fig. 57), to which water can be taken at moderate expense.

The difficulty of obtaining title to vacant lands lying in compact bodies has to a certain extent prevented development and retarded settlement. In recognition of this fact, which, as previously pointed out, prevails in other States, Congress passed what is known as the Carey Act. This law, approved August 18, 1894 (Stat. L., vol. 28, pp. 422, 423), gives to each State containing desert lands the right to select upward of 1,000,000 acres upon certain conditions, the principal of these being that not less than 20 acres of each 160-acre tract shall be cultivated by actual settlers within ten years. The provisions governing the selection and reclamation of these lands have, however, been

found to be of such stringent character that even in Wyoming it has not been found possible to proceed. A number of selections have been made by the State officials, and it has been ascertained that it will be practicable to reclaim large areas in various parts of the State if the act donating the land can be amended in some of its details. The total area vacant, as shown on page 489, comprises over 53,000,000

FIG. 57.—Big Horn River, Wyoming.

acres, so that even if the State should succeed in utilizing the whole of the million-acre grant this will not diminish the area of vacant public land by more than 2 per cent. The water supply, as noted above, is large, and has been estimated to be sufficient under ordinary circumstances to irrigate 9,000,000 acres, this being from two to three times the extent of the lands now in private possession.